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The Public Lighting Tables of the American Meter Company will be found in the page advertisement of that Company.

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[OFFICIAL NOTICE.]

Second Annual Meeting of the Texas Gas and Electric Light Association.

OFFICE OF SECRETARY, GONZALES, TEX., March 28, 1896.

The following is a partial list of papers prepared for our second annual meeting, which will be held at Dallas, Tuesday and Wednesday, May 12 and 13, 1896:

"Electric Light Companies and their Consumers," by Mr. L. T. Fuller, of Calvert.

"Fixed and Variable Expenses in Manufacturing Plants," by Mr. Thos. D. Miller, of Dallas.

"Our Association," by Mr. A. E. Judge, of Tyler.

It is understood that Mr. Bauer, of Texarkana, Mr. Cullinane, of Denison, and Mr. Lord, of Fort Worth, will have short papers.

Such papers as are forwarded to the Secretary 20 days before the meeting will be printed (in sheet form) and a copy mailed to each member.

The "Question Box" is open to all, and will be quite a feature.

The question of a "Wrinkle Department" (among other matters) will come up, and it is expected that all who have originated, adapted or adopted some useful method or device will come prepared to tell about it. The meeting will be called to order promptly at 10 A.M., Tuesday, May 12.

The names of the following gentlemen as Committee of Arrangements, Thos. D. Miller, H. L. Monroe, J. C. Lord, are guarantees that nothing will be left undone for the comfort and convenience of members and visitors. This Committee will make all necessary arrangements as to details of programme for both days, secure headquarters, look after hotel rates, etc. HOMER W. STARR, Sec'y.

[For additional information respecting the meeting of the Texas Gas and Electric Light Association, see page 696.]

[OFFICIAL NOTICE.]

May Meeting, Guild of Gas Managers.

OFFICE OF THE SECRETARY, April 30, 1896.

The May meeting of the Guild of Gas Managers will be held in Young's Hotel, Boston, Mass., at noon, Saturday, May 9.

A. K. QUINN, Sec'y.

[OFFICIAL NOTICE.]

Nineteenth Annual Meeting, Western Gas Association.

OFFICE OF THE SECRETARY, NEW ALBANY, IND., April 28, 1896.

The nineteenth annual meeting of the Western Gas Association will be held at Lookout Mountain, near Chattanooga, Tenn., May 20, 21 and 22, 1896, and will be called to order by the President, Mr. A. W. Littleton.

Lookout Inn will be the Association headquarters, and the business sessions will be held in a detached building, closely adjoining the hotel.

The rates at Lookout Inn will be from $2.50 to $4 per day, with a special rate of $2 per day for the wives of the members who may be present.

The Executive Committee met at St. Louis last January, and, as a result, the following papers will be presented for the consideration of the members:

"Self-Education in Gas Engineering," by Mr. Alex. C. Humphreys, New York City.

"Municipalities vs. Gas Companies: Their Reciprocal Relations," by General A. Hickenlooper, Cincinnati, O.

"The Future of the Gas Business in America," by Mr. M. S. Greenough, Cleveland, O.

"How will the Manufacture of Calcium Carbide Affect the Gas Business?" by Mr. Fred. Bredel, Milwaukee, Wis.

"The (Alleged) Law of Inverse Squares," by Mr. B. E. Chollar, St. Louis, Mo.

"Wrinkle Department," edited by Mr. Geo. T. Thompson, St. Louis, Mo.

The Southern States' Passenger Association, Central Passenger Committee, Chicago and Ohio River Traffic Association, Trunk Line and Chicago and Alton R. R., from all points in Illinois, have granted the usual rate of 1⅓ fare, on the certificate plan, for the round trip to *Chattanooga*, conditional on 100 certificates being presented to the Secretary.

The territory embraced by the Southern States' Passenger Association includes all lines east of the Mississippi river and south of the Ohio and Potomac rivers.

The territory of the Central Passenger Commitee and the Chicago and Ohio River Traffic Association is bounded, on the east, by Pittsburgh, Salamanca, Buffalo and Toronto, on the north by the line of, and including points ont he Grand Trunk Railway from Toronto to Port Huron; thence, via Lake Huron and Michigan, to the north line of Cook county, Ills.; on the west, by the west line of Cook county and the Illinois and Mississippi rivers to Cairo, including Burlington, Keokuk, Quincy, Hannibal and St. Louis; and on the south, by the Ohio river, but including all points on either side of that river.

The Trunk Line territory is as follows: From Niagara Falls, Buffalo and Salamanca, N. Y., Pittsburgh, Pa., Bellaire, O., Wheeling, Parkersburgh and Charleston, W. Va., and points east thereof, except in New England.

All persons availing themselves of the reduced rates will apply to agent at least 30 minutes before departure of train. Certificates in accordance with above arrangement will not be honored, returning home after May 26. All ticket agents do not have a supply of certificates, but they may be obtained by request, if notification is made in time.

The New England Passenger Association refused the request for reduced rates. All persons in the above territory, or territory not embraced by the Passenger Associations mentioned, will purchase tickets

to nearest important station in one of said Associations, and from there purchase a first-class ticket to Chattanooga, paying for same full fare, receiving from the ticket agent a certificate stating that full fare had been paid to Chattanooga, which certificate must be given to the Secretary before the afternoon of Thursday, May 21, so that the Agent of Southern States' Passenger Association may sign certificate, which will entitle the purchaser of ticket to a one-third rate from Chattanooga, returning to the station from which ticket was purchased, providing 100 certificates are presented for signature.

All tickets must be purchased to Chattanooga, and *not* to Lookout Mountain. The various Passenger Associations grant reduced rates only to Chattanooga, from which place Lookout Mountain can be reached by the Chattanooga and Lookout Mountain R.R., which connects, at Union and Central Depots, with all the principal trains from the North and West. Mr. M. S. Gibson, Manager of Lookout Inn, agrees to take charge of all baggage at Chattanooga and relieve our members of the responsibility of rechecking. He writes as follows: "We shall have men at the Union and Central Depots in Chattanooga to receive the checks of your members when they arrive there, and take charge of their baggage, bringing it directly to the Inn, relieving them of all care and responsibility. Our standard gauge train leaves both the Union and Central Depots on the arrival of the principal trains from the North and West, so that passengers can be transferred directly from their trains to our train and taken to the Mountain in 40 minutes' time after their arrival. If the members or any of them arrive on trains that we do not connect with, our porters will be there to show them the way to the electric cars, which run every 15 minutes from the depots in Chattanooga to the foot of the Mountain, there connecting with the new 'Incline No. 2,' which will bring them directly to the door of the Inn, and is a very pleasant way of getting to the Mountain. These cars run every 15 minutes, from 7 A.M. to 10 P.M., and later if desired. All you have to do is to inform your members that, if they will make themselves known when they arrive in Chattanooga, we will see that they arrive at their 'haven of rest' without delay or difficulty. The fare from Chattanooga to Lookout Inn, via Lookout Mountain and Chattanooga Railroad, is 30 cents; round trip, 50 cents."

Mr. James Forbes, Chairman of Committee of Arrangements, announces that he or Mr. I. S. Post will meet the special train, which will be run from Cincinnati, under the direction of Mr. E. H. Jenkins, Supt. Gas Company, Covington, Ky. He will also meet the delegation from St. Louis. Mr. Forbes also states that "Incline No. 1" will give a low round trip rate, and will deliver all baggage from foot of "Incline" to Lookout Inn free of charge. Checks can be given to the Transfer Company's agent, who will also give a special rate from train to foot of "Incline No. 1," and return.

A meeting of the Board of Directors of the Association will be held at Lookout Inn, at 2 P.M., Tuesday, May 19. The following members are Directors: I. C. Baxter, Wm. McDonald, Geo. T. Thompson, Irvin Butterworth, W. M. Eaton, Geo. H. Harper, Peter Young, O. O. Thwing and Wm. Steinwedell.

An invitation is extended to all members of kindred Associations to be present at our meeting and to participate in the proceedings.

The Question Box is ready to receive inquiries, and it is hoped many will avail themselves of the privilege it affords.

The President has appointed the following Committee of Arrangements: Messrs. Jas. Forbes, I. S. Post, Henry Clay Evans and T. H. Payne, of Chattanooga, Tenn.; Robt. Young, Knoxville, Tenn.; E. H. Jenkins, Covington, Ky.; and Jas. T. Lynn, Detroit, Mich.

The undersigned will be pleased to mail blank applications to any who may wish to join the Association and to reply to all communications concerning the meeting. JAMES W. DUNBAR, Sec'y.

NOTES.—Those who were present at Young's Hotel, on the afternoon of April 25th, when Mr. Charles H. Sprague, of Boston, entertained the Guild of Gas Managers "and others," participated in as thoroughly enjoyable a reunion as it was possible to have. The veteran host easily carried off the honors of the day; nor do we stretch the truth a jot in saying that his three-score and-ten of years were no more to him apparently than were the three-score-minus-ten.——Of course, we could not bear ill-will to General John P. Harbison in any event, but we are sorry nevertheless to have to say that we received cards, announcing his marriage to Vida, the daughter of Mrs. Robert B. Ayer, on the morning of Thursday, April 30th, instead of on the morning of Wednesday, April 29th, on which date the marriage ceremony was performed in Hartford. Although we were "a day after the fair," our very worst wish is the best of good luck to them both.——Mr. E. H. Jenkins, writing from Covington, Ky., under date of April 25th, desires us to say that the special parlor car trip to the rendezvous of the Western Association on the occasion of its nineteenth annual meeting, from Cincinnati to Chattanooga, is an assured success. At the time of writing all the seats in one car have been reserved, and a number booked for the second car. It is expected that at least three cars will be needed to accommodate the party, which will include a goodly number of the gentler sex. It is needless to add that "Ed." will leave nothing undone that should be done to insure the perfect comfort of the voyagers. It is hoped that those who have not yet answered the circular sent to them will at once communicate with Mr. Jenkins, at Covington, Ky., so that ample accommodation will be provided in time well in advance. ——We regret to report the death, on the 19th inst., of Mr. C. E. Stokes, who had been the efficient and untiring Superintendent of the factories of the Welsbach Light Company, at Gloucester, N. J., since those works were started. For three years he battled with cancer with singular heroism. He was in his 39th year, and enjoyed to the full the confidence of his employers, the affection of his friends and the respect of his subordinates.

The Acetylene Theory of Luminosity.

[A paper read before the Chemical Society (England) by Prof. V. B. Lewes.]

Early in 1892, I read before the Chemical Society,[1] a paper in which I showed that in a luminous hydrocarbon flame the baking effect of the outer zone of intense combustion converted a very large proportion of the unsaturated hydrocarbons present in the inner zone into acetylene; the maximum production of this compound taking place just before the commencement of luminosity. In a second paper, communicated to the Royal Society in 1895,[2] I gave experimental reasons for considering that the acetylene so formed, on its decomposition by heat into carbon and hydrogen, was the main factor in producing luminosity, as the heat developed by this decomposition raised the carbon particles to a temperature above that of the flame.

At the time the latter paper was published, I was unaware that any other work had been done in this direction; but I find that Professors Dewar and Liveing, in their beautiful work on the spectra of carbon and its compounds, had to a great extent forestalled the conclusions to which I had arrived from a totally different standpoint. In their paper "On the Origin of the Hydrocarbon Flame Spectrum," they say, when speaking of the flame of cyanogen and acetylene:

Both of these compounds decompose with evolution of heat—in fact, they are explosive compounds; and the latent energy in the respective bodies is so great that, if kinetic in the separated constituents, it would raise the temperature between 3,000 and 4,000. The flames of cyanogen and acetylene are peculiar in respect that the temperature of individual decomposing molecules is not dependent entirely on the temperature generated by the combustion, which is a function of the tension of dissociation of the oxidized products, carbonic acid and water. We have no means of defining with any accuracy the temperature which the particles of such a flame may reach. We know, however, that the mean temperature of the flames of carbonic oxide and hydrogen lies between 2,000° and 3,000°, and if to this be added that which can be reached independently by the mere decomposition of cyanogen or acetylene, then we may safely infer that the temperature of individual molecules of carbon, nitrogen and hydrogen in the respective flames of cyanogen and acetylene may reach a temperature of from 6,000° to 7,000.° A previous estimate of the temperature of the positive pole in the electric arc made by one of us gave something like the same value. * * * The formation of acetylene in ordinary combustion seems to be the agent through which a very high local temperature is produced.

I extremely regret not having known of this most valuable work before; and I take this opportunity—the first afforded me—of drawing attention to it.

I also find that M. Gueguen pointed out in 1884[3] that it was very probable that luminosity in hydrocarbon flames is due exclusively to the production of rays furnished by the molecules of gas highly heated by chemical changes; and that it must be borne in mind that the heating from exterior sources would not suffice, whatever its power. He also draws attention to the fact that luminous combustion is caused by bodies which are endothermic, and from which heat is liberated during decomposition.

In November, 1895, Professor Smithells read a paper before the Chemical Society [*ante*, p. 164], in which he criticizes some of the less important points brought forward by me in my previous papers, and without attempting to disprove the fact that acetylene undergoes luminous decomposition when heated apart from air or oxygen, the principal fact upon which the acetylene theory of the luminosity of hydrocarbon flames is based, he comes to the final conclusion that, if the criticism he offers is just, "then the acetylene theory of luminosity will share the fate of the 'dense hydrocarbon' theory."

The first portion of his paper is devoted to the measurement of flame temperature by means of the Le Chatelier thermo couple, and he comes to the conclusion that the experiments show two things: (1) The fallacious results that may be obtained by not disposing the couple with due regard to the conformation of the zone of flame to be measured. (2) The difficulty of ascertaining the increase of temperature contributed by the chemical changes occurring in any one spot. The first conclusion is self-evident, and the second I have already warmly endorsed in the paper which Professor Smithells is criticising.

He then proceeds to explore the temperature existing in a luminous flat flame of coal gas, using for this purpose a No. 4 Bray's union jet burner, at a gas pressure of 2½ inches of water. As Professor Smithells

1. See JOURNAL, May 23d, 1892, p. 739.
2. See JOURNAL, April 22, 1895, p. 563.
3. See Transactions, Technical Society, French Gas Industry, 1884, p. 142.

considers the temperature determinations which he made as practically valueless, it is not necessary to criticize the pressure used, which should have been 7-10ths rather than 2½ inches. Considering, however, the abnormal character of the flame with which he was dealing, his figures accord fairly well with those I have given as representing the gradual rise of temperature in the inner zone of a luminous flat flame. This is of interest, as the methods employed were slightly different, and the coincidence of result goes some way towards establishing the probability of the figures.

In considering the temperature in the flat flame, Professor Smithells says: "To obtain any useful measurements for this flame, it is obvious that it can be explored in one way only—namely, by laying the junction and the adjacent wires in a horizontal straight line, and introducing it along the flat face of the flame, so that it may be placed with a considerable length of wires immersed symmetrically in any one sheath, and passing through parts of the flame in like condition." Having then taken the temperature of the outer and inner zones in this way, he proceeds to say: "The measurements for the inner parts of the flame above given have only a negative significance. It is obvious that they cannot be true temperatures, as the wires have always to be thrust through the hot outer sheath of flame; and, moreover, the couple would attain, by radiation from the outer walls, a higher temperature than the rapid stream of gas in which it is immersed."

With regard to the first objection, that the wires have to pass through the outer wall of high temperature, and that this will invalidate the reading, I think he is mistaken. There will be nearly an inch of heated wire between the thermo-couple and the point where the wires pass through the outer zone; and it seems to me that any conduction from these bodies will be more likely to take place outward along the cool wire than inwards to the heated zone, so that if an equal length of wire on each side of the weld is heated in order to prevent unequal resistances being introduced, the readings should not suffer much from this cause.

Nor does his second objection appear to me to be in any way a fatal one. If the gases in the inner zone had to pass through a circle or even a belt of high temperature, the objection would be valid; but, inasmuch as the gases are flowing up within a sheath of high temperature which exists even after the inner zone ceases to exist, and which is fairly constant in temperature, these gases will probably be as much exposed to radiation as the thermo-couple.

In taking such readings, the thermo-couple is only exposed in the heated zone for a very short period. It has been pointed out by Le Chatelier that the couple takes up with astonishing rapidity the temperature of the locality in which it is placed; while Mr. Callendar has pointed out that a spiral of platinum wire is a bad radiator, and is exceedingly sensitive to slight changes in temperature. It may be assumed, therefore, that it will not absorb radiant heat with great rapidity, and that the temperatures recorded in the non-luminous zone are not far removed from the truth.

Professor Smithells further accentuates his distrust of these recorded temperatures by saying "the readings are not even comparable, as the flame varies in breadth and thickness from point to point in a vertical plane." The inner zone undoubtedly becomes narrower in the higher regions of the flame, until ultimately the outer walls meet at the top of the flame. But the rise of temperature due to this cause is one of the factors that aid the generation of light in a flame; and if a gas were flowing up a gradually narrowing tube, heated throughout to an even temperature, it would manifestly become hotter the nearer the walls of the tube approached each other. I cannot understand why, because the thermo-couple records this fact, the readings are to be discredited.

In the determinations I made of the temperatures existing in the flame of a No. 6 Bray union jet burner, I did not attempt to take the temperature of the outer zone, as it was manifest that this would be the hottest part of the flame. I felt that it would be hopeless to get any accurate readings of it, as it seems clear that close to the inner zone, where there is the maximum of combustible gas meeting with oxygen for its combustion, there will be the hottest part of the flame, while the admixture of nitrogen, air, and the escaping products of combustion will cause a rapid fall in temperature to the outer portion of this zone, which extends much further than mere observation of the flame would lead one to expect; and that in the outer envelope there are so many graduations of temperature, from the hottest to the coolest portion where combustion is finally extinguished, that it would be impossible to obtain even a general idea of its temperature. The main point I wished to ascertain was the effect this high temperature layer of combustion had on the gases flowing up through the inner zone.

The question of passing the wires of the thermo-couple through this heated layer before the inner zone could be reached, of course presented itself at the commencement of the experiments; and, after trying several methods, including the one adopted by Professor Smithells, I came to the conclusion that the best way of doing it was to make the twist of the thermo-couple very short, and to bend each wire at right angles three-quarters of an inch on each side of the couple, so that on plunging it into the flame an equal length of wire on each side of the twist was equally heated, while the portions of the wire passing through the more highly heated zones were equi-distant from the couple—thus ensuring no unequal resistances being introduced.

In my later experiments, I have employed a fixed stand for the burner and the thermo-couple, so that the exact position of the couple could be accurately determined. In this case the wires come out at the side of the flame, as in Professor Smithells' experiments; but the thermo-couple being fixed immediately over the center of the burner, an equal length of wire is heated on each side of the couple.

The use of the Le Chatelier thermo-couple for the determination of high temperatures is now becoming so general, that a description of the precautions necessary in using it will not be out of place; and in my later experiments these were employed. The thermo-couple was connected in series with a dead beat galvanometer—Ayrton and Mather's pattern—having a resistance of 304 ohms; and in order to bring the deflections for the high temperatures within the limits of the scale, a further resistance of 309 ohms was included in the circuit.

The galvanometer was calibrated by means of a cell of small internal resistance and a box of high resistance coils; and, on plotting out the currents and deflections, a straight line was obtained; showing that within the limits of the scale the deflections were directly proportional to the currents. The platinum and platinum rhodium wires used for the thermo-couple were 0.011 inch, or 0.279 mm., in diameter, which is the thinnest that can be used without fear of fusion at the highest temperature of the flame. The resistance of the platinum wire per meter was 1.71 ohms; that of the platinum rhodium wire being 3.6 ohms. In the experiments described by Professor Smithells, the total resistance of wire and galvanometer was about 4 ohms, which enormously increases the risk of error.

The galvanometer and lamp being fixed on a stand, so as to give no possibility of displacement, the couple and galvanometer were calibrated for temperature; the fixed points selected being the following:—

Boiling point of sulphur	444.5° C.
Melting point of pure silver	945.0° C.
" " copper	1045.0° C.
" " palladium	1500.0° C.
" " platinum	1775.0° C.

The melting points of the compounds of the alkalies and alkaline earths vary so widely, as determined by different observers, that they are practically useless for this purpose; and, as there seemed to be some doubt as to whether the E.M.F. of the thermo-couple is directly proportional to temperature above 1000°, I made 13 determinations of the fusing point of palladium, and 16 of platinum. On plotting out a curve for the temperatures, I obtained a straight line for all except the palladium, which was above the line. L. Holborn and W. Wein find the melting point of palladium to be 1587° C.; and had this figure been taken, it would have been close to the same line as the others. From this, I think it is safe to assume the course of the curve continues in a straight line above 1000° C.

In continuing his paper, Professor Smithells proceeds to criticise the values which he obtained for the outer envelope of the flame, and by testing this portion with a thin platinum wire, which he heats to fusion, he comes to the conclusion that his results give a temperature slope opposite to that given by the thermo-couple—*i. e.*, that the hottest portion of the outer envelope of the flame is near the bottom. He explains this as being caused by variations in the thickness of the outer sheath of combustion.

In supposing that this is so, I think Professor Smithells is right as to his facts, but wrong as to the causes to which he ascribes them, as the combustion which gives the outer envelope to the flame in the lower half is mainly due to marsh gas and hydrogen diffusing out from the gas itself; while in the upper portion of the flame it is due to carbon monoxide and hydrogen produced by the actions in the flame—the combustible gases being diluted by the products of the actions taking place. One would expect, therefore, that the lower portions of the non-luminous envelope would be hotter than the upper, although in point of fact, the temperature differs but little, as the accumulation of heat from the combustion going on in the lower part of the flame tends to increase the temperature of the upper portion.

I am in entire accord with Professor Smithells' conclusion that "there are two separate heat gradients in a luminous coal gas flame, one on the vertical axis, which is, in all probability, a steady decline from the top to the bottom; the second on a horizontal axis, showing, as we proceed from the center of the unburnt gas, a steep ascent to the point of contact with the luminous sheath, then a still steeper ascent to the point of contact with the mantle, where the highest point is abruptly attained." That the temperature gradient on the vertical axis is a steady decline from top to bottom, is perfectly clear from both our experiments, while that there is a second gradient in a horizontal axis, with the coolest point in the center of the flame (which is at the greatest distance from the source of heat), is, I think, a foregone conclusion, and I cannot conceive any other condition.

The second conclusion is that the temperature of the mantle of a coal gas flame is above the melting point of platinum; and cannot, therefore, be determined by a thermo-couple in which platinum is one of the elements. Professor Smithells' own experiments show that his thermo-couple registered a temperature there of 1478° at the bottom of the sheath to 1613° at the top of the flame; and thus his assumption that the temperature exceeds that necessary for melting platinum, is dependent on the melting in the outer mantle of very fine platinum wire.

In my previous paper, I have shown the influence which the thickness of the platinum and platinum rhodium wire used has on the temperature recorded; and I have clearly pointed out that, in all the experiments quoted in that paper, wires having a diameter of 0.011 inch, or 0.279 mm., were employed. Professor Smithells uses wires of nearly double this thickness, and obtains a recorded temperature of 1838° before his couple fuses. This, if corrected to the thickness of wire I employed, would be over 2000°. This is caused by the larger cross section of the wire, which is in the ratio of 3.2 : 1, which would lead to a proportionately larger amount of heat being lost by conduction. I found that during the determinations of the deflections corresponding to the fusion of platinum, great care had to be exercised in raising the temperature of the junction exactly to the melting point. It was, in all cases, the platinum of the junction which fused first; and in some cases the platinum rhodium wire was surrounded by a film of melted platinum. It was easy, by carefully heating the junction with a small oxyhydrogen flame, to obtain readings far above the mean obtained for the melting point of platinum; showing that, although the platinum was in the liquid state, a thermo-current was obtained of greater strength than at the temperature of the simple fusion of platinum.

Professor Smithells makes a strong point of the fact that luminosity does not commence suddenly at a certain height, but appears as an envelope just below the inner surface of the outer zone, while the non-luminous zone continues inside the luminous zone to a considerable height in the flame. This manifestly must be so, as the decomposition of the diluted acetylene only takes place as particles stray close to the point where the highest temperatures exist; and as the center of the inner zone is below the necessary temperature, the decomposition of this compound only takes place close to the point where the two zones coalesce. If flames of various illuminating powers are examined, it will be noticed that the greater the light emitted—that is, the richer the flame is in acetylene—the more marked is the commencement of luminosity; so that, although the luminosity begins as a yellow haze with a poor coal gas flame, it commences almost at a sharp line with a rich acetylene flame.

In concluding this portion of his paper, and in order to show the untrustworthy nature of the temperatures thus recorded, Professor Smithells takes two sets of the determinations of temperature existing in flat flames, made at periods three years apart—the one with coal gas burning from a No. 0000 Bray, the other from a No. 6 Bray; and he feel surprised that they do not show "parallelism." The temperatures given are:

	No. 0000 Bray.	No. 6 Bray.
Non-luminous zone	1,023°	1,014°
Commencement of luminosity	1,658°	1,267°
Top luminous zone	2,115°	1,368'
Luminosity	Practically nil.	About 13 candles.

When a flame of coal gas is spread out in an extremely fine sheet, as when burning from a No. 0000 Bray, the amount of air required for the complete combustion of the gas is much more quickly obtained, luminosity is considerably reduced, and a far higher temperature is attained, while the commencement of the feeble band of luminosity is also thrown far nearer the top of the flame, and must therefore be at a higher temperature. Had there been what Professor Smithells is pleased to call "parallelism," it would have given good grounds for suspecting the worthlessness of the determinations. Moreover, a thicker wire was used in the determination taken with the No. 6 Bray in 1892, and I have fully indicated the result of this.

An effective point is made by pointing out that one of these temperatures is 330° above the melting point of platinum, as determined by Violle. In any determination of the temperature of the luminous zone, the reading has to be taken with the greatest rapidity, as otherwise the formation of carbon on the couple causes a falling off in the temperature recorded. In the case instanced, the spot of light rapidly rose to the division which had been calibrated as 2,116°, and then fell with great oscillations. On removing the soot from the couple after cooling, it was found that the wires were welded together, and the platinum fused over the surface of the platinum rhodium, the couple having evidently been only just saved from complete fusion by the deposition of the carbon.

The thermo-couple records with great rapidity the temperature attained by the outer surface of the metals; and it by no means follows that the moment needed to do this should be sufficient to raise the whole mass of metal to the melting point. In my last paper, several temperatures of between 1,800° and 1,900° are recorded; and Professor Smithells fails to call attention to these, I presume, because he found in his own experiments, using wire of nearly double the thickness, that the couple recorded 1,836° before fusion of the platinum in a hydrogen flame, while had he employed an oxyhydrogen flame, so as to very rapidly heat the couple, he would have found it easy to obtain still higher readings. I can only again repeat the statement made in my previous paper, that although flame temperatures taken by the Le Chatelier thermo-couple may be totally incorrect, they are, at any rate, comparable when proper precautions are taken in the methods of using the couple.

In the second part of his paper Professor Smithells deals with other portions of my paper, and summarizes his conclusions as follows: "The description of the structure of a flame adopted by Professor Lewes is not in harmony with the facts." In the 1892 paper before referred to, on "The Luminosity of Coal Gas Flames," I gave the description of three zones of a luminous flame in the words to which Professor Smithells takes such strong exception. In quoting this description, however, he entirely ignores the fact that the seven pages following are devoted to explaining the action of the air in rendering hydrocarbon flames non-luminous, this being done by tracing the action of the diluents in destroying the luminosity of hydrocarbon gases in the Bunsen flame.

The results obtained make it perfectly clear that the outer zone of combustion must be the hottest part of the flame. But it is also manifest that, between the layer of maximum temperature and the cool air, there must be many gradations of temperature; and though I now realize that the outer zone of a flame extends farther than I thought at that period, and that, therefore, the amount of products of incomplete combustion are extremely minute, I still believe that infinitesimal traces of carbon monoxide do escape combustion, and make themselves felt by delicate constitutions. All my papers also clearly show that I consider it is the baking influence of the heat of combustion, generated in the outer zone of the flame, which leads to the changes taking place in the interior of the flame; and I fail to see why Professor Smithells should desire to make it appear that I look upon the outer zone of the flame as the coolest, instead of (as it undoubtedly is) the hottest part of the flame.

I should now be inclined to describe a coal gas flame as consisting of two zones: (1) The outer envelope of combustion. (2) The inner region of non-combustion. The outer zone is the portion of the flame where the combustible gases present in the original gas, or generated by actions taking place in the inner zone, meet with the air and undergo combustion, forming an envelope of intensely high temperature but of no appreciable luminosity.

The maximum combustion takes place towards the inner side of the outer zone, as it is here that the largest proportion of the hot gases meets the oxygen of the air; the dilution and cooling effect produced by the air and products of combustion rapidly causing the external portions of this zone to fall in temperature until finally extinguished. The lower portion of the outer zone is chiefly due to hydrogen and methane which have diffused out from the coal gas undergoing combustion; while the upper portion of the outer zone is fed by carbon monoxide and hydrogen, formed by the decompositions and interactions taking place in the inner zone.

The inner zone is the region into which no oxygen penetrates; and in it many decompositions take place, due to the baking action of the heat generated in the outer zone, and to interaction with the products of combustion. This zone may be subdivided into three parts—

(A) The non-luminous portion, in which the heavy hydrocarbons flowing upward from the burner rapidly increase in temperature owing to radiant heat from the outer flame walls, and are converted thereby into acetylene.

(B) The luminous portion, which is produced by the acetylene formed in the flame being heated to a temperature at which it is decomposed with such rapidity that the particles of carbon liberated are raised to incandescence by the heat generated by its own decomposition, the carbon particles being afterward consumed by the carbon dioxide and water vapor diffusing into the flame from the outer zone, yielding carbon monoxide and hydrogen, which, together with the hydrogen liberated from the acetylene, give, by their combustion, the upper portion of the outer zone. This portion of the inner zone will only be formed near the point of maximum temperature, and therefore forms, in close contact with the outer zone, a sheath or cone which caps the non-luminous part.

(C) The blue region at the base of the flame, which has, I believe, been generally ascribed to the hydrocarbons being consumed without liberation of carbon by the oxygen of the air. I am afraid that I am here again at variance with the generally received ideas, as I believe this portion of the flame to be a continuation of the luminous portion in which the carbon dioxide and water vapor from the outer zone burn up the hydrocarbons to carbon monoxide and hydrogen before the temperature has risen sufficiently to decompose them into carbon and hydrogen.

If a luminous gas flame is turned down low, it is seen that, as the luminosity disappears, the blue region surrounds the inner zone, while it is in turn surrounded by the outer zone (an observation due, I believe, to Hildegard), and the small flame is rendered non-luminous because there is not a sufficient body of heat to convert the hydrocarbons into acetylene, or if acetylene is formed, to decompose it before combustion. It is assumed, with a luminous flame, that no oxygen penetrates through the outer zone; and as the outer zone still exists with the small flame, I fail to see why enough oxygen should enter to burn up the hydrocarbons before liberation of free carbon.

If a flame of acetylene be burnt at the end of an open tube and carbon dioxide be allowed to gently flow up a second tube into the center of the flame, the first addition destroys the smoky lurid nature of the flame, and gives a slight increase in luminosity, which gradually dies away as more carbon dioxide is introduced, until a non-luminous flame results; while if carbon dioxide instead of air be supplied to a Bunsen burner through the air holes, the luminosity is destroyed and the flame has all the characteristic color of the blue part of the inner zone.

It is a significant fact that Professor Smithells, in his second objection, considers the amount of acetylene present in a luminous flame insufficient to account for the light emitted, without taking the trouble to perform, or at any rate record, a single experiment in support of his unbelief.

The statement made by me that, just before luminosity commences, 80 per cent. of the unsaturated hydrocarbons present at that spot consist of acetylene, is characterized as "likely to give a very false impression as to the importance to be attached to the presence of this gas," as Professor Smithells is at a loss to understand how a mixture of 1.5 per cent. of acetylene and 0.5 per cent. of other unsaturated hydrocarbons mixed with 98 per cent. of other gases, four-fifths of which are actually incombustible, could be supposed to have the properties I attribute to it.

If he means by this that the liberated carbon particles in the flame are not derived from the small quantity of acetylene, it seems hardly logical to suppose that they come from the 0.5 per cent. of other unsaturated hydrocarbons; and if they do not come from the unsaturated hydrocarbons at all, perhaps Professor Smithells will be able to explain their source.

If a mixture of 1.5 per cent. of acetylene with any combustible gas which gives a non-luminous flame were burnt from a jet, no luminosity would be developed by the flame, and no trace of acetylene found at the top of the inner zone—it having been all consumed or polymerized before the temperature necessary for its decomposition was reached. But it is nevertheless a fact that 1.5 per cent. of acetylene, *present at the spot where luminosity usually commences*, will render such a flame luminous. In an acetylene flame the nitrogen and products of combustion diffusing into the flame dilute the acetylene present at the commencement of luminosity to 15 per cent. of the gases present at that point; and the acetylene flame gives more than 10 times the light of the gas flame with its 1.5 per cent.

In an analysis made by me of the gases present in the non-luminous gas flame just before luminosity commences, I found 18.65 per cent. of combustible gas; whereas Landolt, in his experiments on the same portion of the flame, only found 10.01 per cent.

	Lewes.	Landolt.
Hydrogen	2.35	2.59
Methane	7.80	0.79
Carbon monoxide	6.52	5.45
Unsaturated hydrocarbons	1.98	1.18
	18.65	10.01

Landolt also notes the fact that the gas from the lower portion of the flame is free from smell, but that from the higher portions has a feeble empyreumatic odor. I should have thought that the small proportion of combustible gases present at this point was an important proof that luminosity must be due to some such action as that to which I have ascribed it, rather than to any ordinary combustion.

In order to see if 1.5 per cent. of acetylene injected into the upper portion of the non-luminous zone of de-illuminated coal gas restored its luminosity, coal gas was slowly passed through washing flasks containing a solution of bromine in potassic bromide until its illuminating power was reduced to 1.7 candles. Two open tubes were then arranged side by side, and ordinary coal gas burnt from one, and de-illuminated coal gas from the other, in flames of equal size, and acetylene was then allowed to flow through a fine platinum tube into the inner zone of the de-illuminated gas flame, at such a rate as to form 1.5 per cent. of the gases present; the result being that the flame became nearly as luminous as the one used for comparison.

Another point insisted upon by Professor Smithells is that "there is no evidence of any local condition of temperature within the flame such as would point to the decomposition of acetylene with the evolution of much heat." In order to see exactly what the increase of sensible heat, at the moment of decomposition, of pure acetylene amounted to, I arranged a thermo-couple in a small, hard glass tube, passed acetylene through the tube until free from air; and while the gas was burning at the exit of the tube, heated 6 inches of the tube in such a way that the thermo-couple should be at the spot where the acetylene entered the heated zone. The luminous decomposition commenced, as is usually the case, about two-thirds of the way up the heated zone, and the glow slowly ran back to the commencement of the heated area. On coming in contact with the thermo-couple it gave a rise of temperature of 30° as the mean of three closely concordant experiments. It is evident from this experiment that no very high local condition of temperature would be found in the flame at the spot where the decomposition of the acetylene took place.

The fourth conclusion has been already fully dealt with.

In his fifth conclusion Professor Smithells says: "The conclusion in favor of the acetylene theory, based on the comparative luminosity of ethylene and acetylene flames, is due to neglect of the consideration that in the latter there are higher temperatures, and a greater relative amount of carbon."

When acetylene and ethylene are burnt at the same rate of flow from similar burners, a certain portion undergoes non-luminous combustion, in order to supply the heat necessary in the one case to form acetylene and then decompose it, and in the other to decompose it only. That far more ethylene is needed to do this work is manifest from the size of the non-luminous zone, which is many times greater than that of the acetylene flame.

The portion of the gas undergoing non-luminous combustion generates heat only, of which but little is radiated. The portion converted into acetylene, and decomposed, gives off its energy to a considerable extent by radiation. Hence, although the heat of combustion of acetylene may be far higher than the heat of combustion of ethylene, it is conceivable that the acetylene flame may develop but little more heat than a flame of ethylene of the same size.

The figures I gave were for the interior of the flame only, and I quite agree that the outer envelope of the lower portion of an acetylene flame must be hotter than the same portion of an ethylene flame. But it by no means follows that the total heat developed by the acetylene flame is much greater than that developed by the ethylene. Ethylene and acetylene both contain two atoms of carbon in the molecule, and if we do not assume some such theory as the one proposed we might be led into the error of supposing that the luminosity of the ethylene should be only one-half that of acetylene, because the carbon is diluted with twice the volume of hydrogen, whereas experiment shows its illuminating value is only one-quarter.

Professor Smithells argues that, because a platinum wire glows nearly as strongly in the lower portion of the outer envelope of an acetylene flame as the carbon particles within that envelope, the heat

of the flame is sufficient to raise them to this high degree of incandescence. This assumption is apparently based on the idea that they both have equal powers of emitting light when heated to the same temperature. This is about as reasonable as supposing that carbon has the same emissive powers for light as the earths used in a Welsbach mantle. It is also evident that the platinum wire must be heated to a higher temperature in the outer envelope of the flame than the carbon particles which are within it. Metals at a high temperature have been shown to reflect light, and it is quite possible that some of the apparent brightness of the platinum wire is due to light reflected from its surface.

In arriving at his sixth conclusion, Professor Smithells has repeated an experiment described by me, and he finds that "the indirect evidence deduced from the behavior of cyanogen arises from the yellow ammonia flame having been mistaken for one containing solid carbon." When a cyanogen flame issuing from a small jet has hydrogen supplied around it, the inner rose-colored cone becomes luminous; and on examining by means of a spectroscope the light emitted a continuous spectrum is obtained in which the nitrogen lines are faintly visible. If now the hydrogen be increased in quantity, the flame enlarges, the luminosity becomes fainter and more spread over the flame, and the light emitted no longer gives a continuous spectrum, but only the nitrogen lines.

If the flame emiting the continuous spectrum be now surrounded with oxygen, the luminous inner zone shrinks in size, and emits an intense light, which gives a bright continuous spectrum with flutings which correspond to the cyanogen lines. This experiment is best performed with a burner made of three concentric platinum tubes; cyanogen being supplied to the central, hydrogen to the middle, and oxygen to the outer tube.

Professor Smithells has repeated this experiment, but apparently has only dealt with the cyanogen flame in presence of a large excess of hydrogen; and, noting that the luminosity was low and of a yellowish color, he attempted to deposit carbon from it upon a cold porcelain dish. Failing to do this, he then fed a hydrogen flame with ammonia, obtained a similar appearance in the flame produced, and on examining both flames with a spectroscope, obtained identical lines, which he says are those of ammonia. From these facts, he argues that in the above experiment an ammonia flame has been mistaken for one containing solid carbon.

These experiments, I think, are entirely fallacious. If a hydrogen flame be taken, and ethylene be passed into it until it is endowed with the same, or even far higher, luminosity than the hydrogen flame fed with cyanogen, it is impossible to deposit carbon particles from it by immersing in the flame a cold porcelain surface, because the intense power the excess of heated water vapor present in the flame has of oxidizing the solid carbon particles is so great that no deposition is possible. This result is therefore no proof of the absence of carbon particles.

The spectra given by the cyanogen and ammonia fed into hydrogen flames are unquestionably identical, and on comparing them with the spectrum of nitrogen given by a Geissler vacuum tube, they were found also to correspond with the spectrum given by this gas. The evidence produced by Professor Smithells to show that ammonia (and not the carbon particles) is the cause of luminosity, is therefore of no value; and his assumption that the increased luminosity obtained when the dual flame is fed with oxygen is due to sodium vapor from the platinum, is also absolutely devoid of foundation.

It is evident that, in the experiment properly performed with hydrogen alone, we are dealing with temperatures only just sufficient to lead to luminosity, and a piece of cold metal placed against the inner cone causes it to again become non-luminous. But if hydrogen be replaced by carbon monoxide, no luminosity ensues—a fact which might be taken to support Professor Smithells' views, were it not that a slight increase of temperature leads to luminosity, as when the dual flame is surrounded with oxygen; while a still further increase in temperature not only again increases the luminosity but enables one to obtain a copious deposit of carbon from the flame.

This is readily done by burning the cyanogen from the end of a tube and surrounding it with nitric oxide—the decomposition of this endothermic body (the heat of formation of which is—4575°) raising the temperature of the flame to a point at which the cyanogen burns with a dazzling light, and with the flow of cyanogen and nitric oxide properly regulated, it can be made to deposit soot in abundance. (This soot contains a trace of para-cyanogen. In order to obtain a deposit, the cyanogen and nitric oxide must be pure.) The continuous spectrum given by this flame is of a most magnificent character, showing brilliant flutings in the red and green, and extending with particular brilliancy far into the violet; and when the light is developed from a burner of the kind before described, by using quartz lenses and prisms, the spectrum may be projected upon a screen.

I think there can be no doubt, from these experiments, that I was perfectly correct in my former statement that the luminosity of a cyanogen flame is purely a question of temperature, while I have no doubt that, given sufficient heat to rapidly decompose it, as high an illuminating value as that of acetylene would be obtained.

The seventh conclusion arrived at by Professor Smithells is that "the theoretical arguments based on thermo-chemical considerations are invalid." In my paper, I incautiously speak of carbon existing in a molecular state of division—meaning, as the context clearly shows, exceedingly small particles of solid carbon. But Professor Smithells does not fail to make the most of this slip, and supposes that it is a periphrasis for "carbon in the form of gas;" and that, if so, it sounds the keynote of much that follows, as, while I continue to speak of solid particles of carbon, my theoretical speculations are applicable only to atoms.

I am not aware that, when atoms of carbon form molecules, a disappearance of heat takes place. My general impression was that when gaseous matter assumed the solid form, heat was evolved rather than absorbed; and as these are the only factors which would invalidate my arguments, I fail to see what Professor Smithells means. Moreover, I carefully point out in my paper that I consider these theoretical calculations of "no value, except as showing that a ratio does exist between heat of formation and illuminating value."

Professor Smithells' last conclusion is that "the phenomena of luminous hydrocarbon flames can be adequately explained without the acetylene theory." If by this it is meant that, because an imperfect explanation already exists, no one is to attempt to render our knowledge more exact, it seems to me so utterly opposed to the whole spirit of scientific inquiry, that I think it best to ignore it, more especially as I fail to see how such an idea can be reconciled with the quotation from his own work with which Professor Smithells commences his paper: "A problem remaining to be studied concerns the exact course of the decomposition of the hydrocarbon in the flame."

In conclusion, I must protest against the statement made by Professor Smithells that I adduce measurements of temperature as the chief basis for the acetylene theory. I have clearly pointed out in the paper criticised that at most they are only valuable for comparison under well defined conditions. I consider the acetylene theory of luminosity in hydrocarbon flames to be based upon the following facts:

1. That the largest proportion of the unsaturated hydrocarbons in a gas flame are converted into acetylene before luminosity commences.
2. That acetylene develops luminosity when heated to a temperature at which it decomposes; the conditions under which this takes place rendering the presence of atmospheric oxygen impossible.
3. That the temperature necessary to decompose acetylene with luminosity is insufficient to raise the carbon liberated from it to the point at which it emits light.
4. That in luminous hydrocarbon flames of sufficiently high temperature the luminosity varies directly with the amount of acetylene present where the luminosity commences.

Professor Smithells has not attempted to experimentally refute any one of these points; and until this is done, I, at any rate, shall consider that the "acetylene theory" offers a satisfactory explanation of the most important phenomenon of luminous hydrocarbon flames.

I desire to express my thanks to Mr. A. Haddon, Demonstrator of Physics at the Royal Naval College, Greenwich, for the help he has afforded me in the work entailed by this paper.

The Combustion of Coal and Gas in House Fires.

[A paper read by J. B. Cohen, Ph.D., and G. H. Russell, A.I.C., before the Yorkshire Section of the Society of Chemical Industry.]

The object of the following experiments was, in the first place, to redetermine the extent of pollution of town air by smoke arising from house fires burning coal; and, secondly, to find if a more extensive use of gas fires might be recommended by way of mitigating or removing this evil.

Coal Fires.—A few determinations of the amount of soot given off from a good quality of Yorkshire house coal (Silkstone Hards) were made by Mr. G. Hefford, in 1893. Cotton-wool plugs were employed for collecting the soot from the fire. Subsequently one of us found that

the exceedingly hygroscopic character of cotton wool might, in view of the small quantity of soot in proportion to that of the wool, lead to appreciable errors unless dried and weighed with special precautions. Another source of error in the former determinations might have arisen from the fact that the carbon dioxide in the chimney gases was determined in samples drawn occasionally, and might therefore not accurately represent the average amount of carbon dioxide passing up the chimney during the whole period of combustion. It was consequently thought desirable to repeat the determinations so as to avoid these possible sources of error, and to extend them so as to include house coal from the Durham and Lancashire coal fields.

The results may be summarized briefly as follows;

Using a similar kind of coal to that employed in the former determinations, the weight of soot per 100 liters of chimney gases and the percentage of CO_2 were both found to be much lower than in the previous determinations. The net result has been to raise the percentage of soot on the carbon burned from 5 to an average of 7.7 per cent. on this particular quality of coal. The average percentage of soot in 12 analyses, including 8 of Yorkshire coals, 2 of Durham coals, and 2 of Wigan coals, amounted to 6½ per cent. on the carbon burned. The quantity of soot obtained in different experiments with the same kind of coal varies, as will be seen from the table. It is no doubt influenced by the manner of firing and by the amount of draught. There was no slack in any of the samples.

The determinations were carried out as follows: The chimney gases were aspirated through a brass tube of about ½ inch in diameter. The end inserted into the chimney was closed and a narrow slit about 3 inches long was cut longitudinally at about 1 inch from the closed end, through which the chimney gases could be drawn. To the open end of the brass tube a glass tube containing the weighed cotton wool plug was inserted. The cotton plug was dried in a weighing bottle in the steam oven, then kept over night in a desiccator over sulphuric acid, and then weighed against another cotton plug dried in the same manner along with the experimental one, and the process repeated until consecutive weighings were constant. The air was aspirated by means of two gasholders, each holding about 15 liters, and the chimney gases were drawn off at the rate of about a liter a minute, which would approach the speed of the gases passing up the flue. The object of this was to prevent a greater deposition of soot in the brass tube than would occur in its progress up the chimney. Before reaching the aspirator a portion of the chimney gases was tapped by a smaller aspirator and made to pass through a drying tube and two weighed potash apparatuses. An average sample of chimney gases was thus obtained in which the CO_2 was determined.

In this way the operation was continued for about 5 or 6 hours, and during the time 200 to 300 liters of chimney gases were aspirated by the large aspirator, of which 5 to 20 liters were drawn through the small one. A good fire was maintained all the time, and the gases were aspirated from the first lighting of the fire.

The following is a tabulated statement of the results:

Number.	Carbon Dioxide.			Soot.		Percentage Soot on C. Burned.	Name of Coal.
	Chimney Gases.	Weight of CO_2.	Weight of C.	Chimney Gases.	Weight of Soot.		
	Liters.			Liters.			
1	10.0	0.045	0.0102	218.0	0 0155	6.9	
2	10.5	0.0435	0.0097	282.5	0.0267	10.2	
3	9.5	0.037	0.0082	249.5	0.0174	8.0	"Silkstone Hards" (Yorks).
4	7.0	0.0485	0.0118	231.0	0.0228	5.8	
5	7.5	0.058	0.0143	164.5	0.0292	9.3	
6	7.5	0.060	0.0148	182.5	0.0219	6.0	
7	5.0	0.037	0.0091	175.0	0.0247	7.7	"Haigh Moor Best" (Yorks).
8	6.5	0.0515	0.0127	278.5	0.0278	5.1	
9	16.0	0.118	0.0289	240.0	0.0243	5.6	"Harvey Seam" } (Durham).
10	6.5	0.053	0.0131	230.5	0.0227	4.8	"Hutton Seam" }
11	6.0	0.0375	0.0090	262.0	0.0282	7.1	"Best Deep Yard" } (Lancs).
12	6.9	0.0475	0.0118	230.0	0.0232	5.1	"Best Arley" }
Total	98.0	0.6365	0.1536	2744.0	0.2844	6.5	Mean.

In column 4 the carbon in the carbon dioxide of the air, calculated at 0.04 per cent. and measured at 20°, is deducted.

Gas Fires.—The use of gas in place of coal has often been suggested as a remedy for the smoke nuisance. Many people profess an objection to gas fires either from experiencing a real feeling of discomfort or from purely sentimental reasons. It has been alleged, moreover, that carbonic oxide is given off into the room from gas fires—a statement which, if true, would manifestly condemn their use. It is impossible to ascertain or explain the cause of, and therefore to controvert, sentimental objections; but the other points may be easily tested—*i. e.*, as to the evolution of carbonic oxide and as to the cause of physical discomfort.

Through the kindness of Messrs. Wilson & Sons we have been able to test their gas stoves for carbonic oxide, and to make a rough comparison between three different species of gas stoves which they supply and coal fires as regards heating effect, from the point of view of economy and health. We may say, in parenthesis, that we have no further object in naming Messrs. Wilson & Sons beyond acknowledging their readiness to supply us with all necessary apparatus and full permission at the outset to publish our results, whether prejudicial to their interests or not.

Carbonic Oxide.—We may state, briefly, that there is practically no carbonic oxide passing from a gas fire—*i. e.*, the volume does not amount to 0.01 per cent. of the flue gases with the full pressure of gas and burning 42 to 44 cubic feet an hour. When the gas is first lighted with slight explosion, and the gases immediately aspirated for about two minutes from the front of the fire above the clay rings, an average of 0.9 per cent. of carbonic oxide was found. Gases aspirated from within the clay rings contained, on the average, 10.5 per cent. of carbonic oxide.

We attach no importance to this, as, from experiments made at the College, samples of gases may be drawn from the interior of a coal fire containing as much as 6 per cent. of carbonic oxide, none of which, with a reasonable chimney, ever finds its way into a room.

It will be readily understood that with a down draught unburned hydrocarbons and carbonic oxide may be wafted into the room from a gas fire and probably also from a coal fire. The following tables contain the experimental results. A preliminary examination of the gases from the gas fires was made with Hempel's gas apparatus, by the palladious chloride and with hæmoglobin tests, with the following results:

I.—*Estimate of Carbonic Acid and Carbonic Oxide with Hempel's Gas Burette.*

	Flue Gases.		Gases from the *Center* of the Fire.
Carbonic acid...	4.5 per cent.	4.7 per cent.	5.07 per cent.
Carbonic oxide..	Trace.	Trace.	(not determined.)

II.—*Palladious Chloride Test for Carbonic Oxide.*

	Flue Gases.			Gases from *Top* of Fire Immediately After Lighting.
Time of absorption.	90 mins.	45 mins.	240 mins.	74 mins.
Indications of carbonic oxide due to blackening.	Very faint gray stain.	Faint gray stain.	Distinct gray stain.	Deep black stain.

III.—*Hæmoglobin Test.*

The flue gases were aspirated through tubes containing calcium chloride, strong sulphuric acid, and soda lime, and finally through a flask containing a solution of blood. Only the faintest indication of the presence of carbonic oxide was detected in 10 liters of the flue gases. It was found possible, by this test, to detect with certainty less than 1 c.c. of carbonic oxide in 10 liters, or 0.01 per cent. We are indebted to Messrs. C. E. Brittain and H. de H. Boyd for carrying out the hæmoglobin test.

IV.—*Quantitative Determination of the Amount of Carbonic Acid and Carbonic Oxide in Flue Gases.*

In these experiments the flue gases were aspirated through a brass tube, of about ½ inch diameter, inserted in the flue pipe about 2 feet

	I.	II.	III.	IV.	V.	VI.
Rate of consumption of gas, cubic feet per hour	44.0	43.6	44.0	42.5	42.2	42.8
Volume of gases aspirated	6,000 c.c.	5,750 c.c.	1,750 c.c.	6,000 c.c.	5,100 c.c.	4,000 c.c.
	Grms.	Grms.	Grms.	Grms.	Grms.	Grms.
Weight of carbonic acid (A)	0.4235	0.4345	0.1125	0.473	0.4078	0.3172
Weight of carbonic acid (B) (oxidized carbonic oxide)	Nil.	0.001	0.0025	0.0067	0.0060	0.0048
Weight of water (C)	0.0105	0.0175	0.0125	0.0052	0.0058	0.0053

above the aperture of the stove. The end inserted in the flue pipe was closed, and a narrow slit, about 4 inches long, was cut longitudinally, through which the gases could be drawn off. After passing the brass tube the gases were aspirated successfully through an empty vessel to condense moisture, drying tubes, containing calcium carbide, and strong sulphuric acid, and eventually the carbonic acid present in the flue gases was absorbed in the weighed potash bulbs (A). After again drying, the residual gases were oxidized by passing over heated copper oxide in an ordinary combustion furnace, the water and carbonic acid thus formed being estimated by absorption in the calcium chloride tube (C) and the potash bulb (B) respectively. The apparatus was finally connected up to an aspirator, and a gentle stream of gas maintained throughout each experiment, the total volume aspirated being measured in each case.

The percentage of carbonic acid is given from the weight of A. If the increase in weight of B is due to oxidized carbonic oxide, the percentages will stand as follows:

Percentages.	I.	II.	III.	IV.	V.	VI.
Carbonic acid	3.58	3.83	3.26	3.91	4.05	4.02
" oxide	—	0.005	0.046	0.036	0.038	0.0385

Average Per Cent.	
Carbonic acid	3.99
Carbonic oxide	0.037

Owing to the large amount of water formed after passing the gases over the hot copper oxide, we concluded that either (1) unburned hydrogen, (2) saturated hydrocarbons, or (3) unsaturated hydrocarbons, were present in the flue gases. We endeavored to prove the presence of olefines in the gases by absorption with fuming sulphuric acid in a Hempel's gas burette, with the following results:

V.—*Percentage of Olefines.*

	I.	II.	III.	IV.	V.
Percentage	0.5	0.3	0.2	0.1	Trace.

It appears, therefore, that there is a small and variable volume of unburned gas in the flue gases, which will account for the formation of carbonic acid and water after contact with the copper oxide, and does not necessarily point to the presence of carbonic oxide.

VI.—*Analysis of the Gases Drawn from the Middle of the Fire.*

	I. Grms.	II. Grms.	III. Grms.	IV. Grms.	V. Grms.	VI. Grms.
Weight of carbonic acid (A)	0.099	0.0675	0.1455	0.340	0.067	0.213
Weight of carbonic acid (B) (oxidized carbonic oxide)	0.424	0.2935	0.5705	0.0985	0.327	0.3585
Weight of water (C)	0.0875	0.1595	0.2675	0.034	0.027	0.1025
Percentage of carbonic acid	Determined by Hempel's apparatus, 5.07 per cent.					
Percentage of carbonic oxide	13.81	14.02	12.65	0.935	15.74	5.43

VII.—*Analysis of the Gases from above the Clay Rings Immediately After Lighting the Fire.*

Percentages.	I.	II.	III.	IV.
Carbonic acid	2.6	6.3	3.0	1.6
Olefines	Trace.	Nil.	Nil.	Nil.
Carbonic oxide	1.0	1.7	0.6	0.4

Comparison of the Heating Effect of Gas and Coal Fires.

Comparative determinations have been made with special reference to—

1. Rise of temperature of the air in different parts of the room.
2. Heating effect by radiation.
3. Dryness of the air.
4. Draught into the chimney.

The gas stoves tested were of the following kind:

A. "Parisien" stove, the special feature of which is a perforated top, through the cylindrical apertures of which a constant circulation of air is effected, which then passes into and helps to warm the room.

B. "Comely" stove, similar to A, but without perforated top.

In both A and B the body of the stove is fixed in front of the old fire grate, and the hot metal will assist more or less in warming the air.

C. "Canopy" stove. This is a new form of gas fire. It has 8 instead of 6 atmospheric burners, as in A and B, but of rather small dimensions, and clay rings; but it is fixed back in the old fireplace, and delivers not only its combustion products directly into the chimney, but the warm air from the hot metal also passes up the chimney. Further, it has a reflex and not a vertical fireclay back, which is much longer than in A and B. In short, it is a shallow coal fire grate burning gas and heating by radiation like a coal fire.

D. The ordinary old-fashioned coal fire grate with vertical back, and both back and sides above the grate of cast iron. In moderately cold weather it consumes about 2 lbs. of coal an hour; with hard firing that quantity would be doubled. Coal gas was Haigh Moor best.

The gas fires, A and B, and the coal fire, were tested on the same day and under approximately the same conditions. Gas fire, C, which had not been made, was tested on a later date along with B and the coal fire.

The results may be briefly summarized as follows:

Draught.—The chimney draught plays an important part in the heating of a room, and we will first refer to this: Although there is a rapid current of air, sufficient to extinguish a lighted taper, through the narrow exit into the flue of the gas stove A and B, which delivers the products of combustion to the chimney, the amount of air from the aperture only passes at the rate of about 3½ cubic feet per minute, measured by an anemometer. The flow of air towards the front of a gas stove was in these two cases so slow as to give no indication whatever with the anemometer. Consequently, if the chimney space behind the gas fire is blocked up, except for the flue pipe, there is practically no ventilation of the room by way of the chimney. On the other hand, if the chimney is not blocked the current of air is as follows:

	Cubic Feet per Minute.	
	Door of Room Closed.	Door of Room Open.
A, burning 22-3 cubic feet of gas	105	123
B, " " " "	133	166
C, " 20 " "	132	160
D, " 2-3 lb. of coal { small fire	160	180
D, " 2-3 lb. of coal { large fire	200	235

Rise of Temperature of the Air.—The average rise of temperature indicated by thermometers (previously compared) and distributed through the room, was as follows:

	Mean Rise of Temperature in Deg. C.			Cubic Feet of Gas Burned.
	1st Hour.	2d Hour.	3d Hour.	
A, January 3	1.82	2.31	....	22½ Moderately Fired.
B, "	1.66	1.81	....	20
D, "	1.00	1.37	1.4	....
B, January 19	2.2	2.6	....	24 Strongly Fired.
C, "	1.4	1.6	....	19
D, "	0.7	2.0	....	....

The sets of experiments on the two days are not comparable, as the initial temperatures were very different, and the rise from the lower temperature in the second set was greater than in the first. As the room is over the kitchen, and gets a certain amount of heat from below, what was thought the least effective heating apparatus was tested last.

Dryness of the Air.—The first set of experiments were made when the outside air was nearly saturated with moisture (temperature, 10.5°; wet bulb, 0.75°). The difference between the wet and dry bulb thermometers in the middle of the room increased with rise of temperature

of the air. The difference, as might have been anticipated, was greatest in the case of A and B in the first set and B and D in the second.

Difference between Wet and Dry Bulbs.

A.....	5.0°	B.....	5.3°
B.....	5.0°	C.....	4.2°
D.....	4.5°	D.....	5.2°

Heating Effect by Radiation.—This was determined by suspending thermometers a yard from the fire at a height of 1 foot and 3 feet above the ground. There was little difference between the gas fires and a bright coal fire, except that the temperature was always rather higher near the floor than 3 feet above in the case of the gas fire, and often the reverse with the coal fire. With an ordinary coal fire a much lower temperature was obtained than with the gas fire burning 20 to 23 cubic feet an hour.

	One Foot above Ground.	Three Feet above Ground.	
B	24.4	22.6	22 to 23 cu. ft. per hour.
C.....	23.0	22.0	20 " "
D	24.5	24.5	Bright fire.
	19.5	20.2	Rather dull fire.

Gas Fire Experiments.—The room measured 14 feet x 14 feet x 10 feet high, and, in addition, a small bow window. The thermometers were compared for correction and distributed as follows: *a*. Middle of the room, 3 feet from ceiling. *b*. Middle of the inside wall, 4 feet from floor. *c*. Middle of the room, 4 feet from floor; wet and dry bulb. *d*. Middle of outside side wall, 4 feet from floor. 3d January, 1896.—Wet and dry bulb outside indicated at mid-day: Wet, 9.75°; dry, 10.5°. Temperature outside varied during the day 10° to 11°. One person was in the room during all the experiments. The temperatures given are in degrees Centigrade.

"Comely" Stove.

Time.	*a*.	*b*.	*c*. Dry Bulb.	*c*. Wet Bulb.	*d*.	Gas Consumed per Hour.
6 A.M.	18.0	18.1	18.25	14.25	18.2	..
7 "	20.1	19.5	20.6	15.6	19.0	20 cu. ft.
8 "	20.3	19.7	20.6	15.6	19.2	20 cu. ft.

The room was allowed to cool two hours and the stove changed.

"Parisien" Stove.

10 A.M.	18.0	17.7	17.7	13.9	17.7	..
11 "	19.6	19.4	20.4	15.5	22.2	22.5 c. ft.
12 noon	20.25	20.0	20.7	15.7	19.4	..

The room was again allowed to cool and the coal fire lighted.

Coal Fire.

Time.	*a*.	*b*.	*c*. Dry Bulb.	*c*. Wet Bulb.	*d*.	Coal Consumed per Hour.
2:30 P.M.	18.25	17.5	17.75	14.0	17.7	About 6 lbs. of coal burned in 3 hours.
3:30 "	19.3	18.7	19.2	15.0	18.2	
4:30 "	19.6	19.2	19.6	15.5	18.5	
5:30 "	20.0	19.2	20.0	15.5	18.8	

January 19, 1896.—The outside temperature varied from 11.7° to 6.5° during the day.

"Canopy" Stove.

5:45 A.M.	15.8	15.5	15.3	11.5	15.3	....
6:45 "	17.4	16.6	17.2	13.0	16.3	19 cu. feet.
7:45 "	17.7	16.7	17.4	13.2	16.5	19 cu. feet.

"Comely" Stove.

Time.	*a*.	*b*.	*c*. Dry Bulb.	*c*. Wet Bulb.	*d*.	
10:35 A.M.	15.4	15.0	14.6	10.7	15.0	....
11:35 "	17.5	17.2	17.6	12.5	16.6	24 cu. feet.
12:35 P.M.	17.9	17.4	17.8	12.5	17.3	24 cu. feet.

Coal Fire.

						Coal Consumed per Hour.
2:30 P.M.	15.8	15.4	15.3	10.8	15.5	About 6 lbs. of coal burned in 2 hours.
3:30 "	16.7	16.3	15.8	12.0	16.1	
4:30 "	17.9	17.5	17.8	12.6	17.0	

The conclusions we arrive at from these experiments may be briefly stated as follows:

1. The draught up the chimney plays an important part in the heating of a room.

2. If the fireplace behind the gas stove is closed, except for the flue pipe, the greatest heating effect is produced; but there is then practically no ventilation by way of the chimney, unless by a special opening into it.

3. If the fireplace behind the gas stove is open the draught up the chimney is considerable, but rather less than with a coal fire.

4. In the last case the heating effect with gas stoves A and B is still greater than with the coal fire—that is, the air of the room is warmed more quickly and to a higher temperature than with the coal fire.

5. The heating effect of a gas fire of type C is less than that of a coal fire.

6. As regards relative cost in Leeds, roughly speaking, gas is 3 times as costly as coal, comparing equal periods of heating; but, as regards heating effect, the cost of gas will be proportionately less. It is doubtful, even then, if gas is less than twice as expensive as coal.

There is no doubt that a higher heating effect with coal may be attained in modern modifications of the coal fire on the "reflex" or "lean-to" back principle with small flue aperture, but we had no opportunity of testing this. In the case of a coal fire the heating is mainly done by radiation, and the air of the room is only slowly warmed by contact with walls, ceiling, etc., reaching, after a time, a maximum, as is seen in the experiment on 3d January, when, during the third hour, no appreciable rise of temperature occurred. With gas stoves A and B, on the other hand, the air gets rapidly warmed, and it is therefore necessary to guard against over-heating of the air by ascertaining the temperature from time to time, and adjusting the gas; for air warmed above a certain temperature is apt to cause a feeling of dryness and discomfort. If the fireplace behind the gas fire is closed so as to get the maximum heating effect, some opening into the chimney should be contrived by making an aperture at the ceiling level. If the above conditions are observed a gas fire is a perfectly healthy heating appliance, more effective and more cleanly, although at the same time more costly than coal. It must be remembered that these experiments on the comparative heating effects of gas and coal fires, although carried out with as much care as the circumstances allowed, do not pretend to absolute accuracy. We believe that the general conclusions are correct.

How to Use a Voltmeter as an Ammeter.

[By Mr. George T. Hanchett, in *Electrical World*.]

It sometimes happens that in testing a dynamo or motor or in other work around a railway power station an accurate ammeter is very desirable. Sometimes switchboard instruments can be pressed into service, but often they are not sufficiently accurate, of limited range, or else they are too urgently required for their present service. In such a case some makeshift like the following may be very desirable, if not imperatively necessary for the work in hand.

If the terminals of a voltmeter are connected with the two ends of a resistance through which a steady current is flowing, a defection will be obtained which in numerical value is directly proportional to the current flowing in the resistance, and which only needs a multiplying factor to give the value of this current. This principle is utilized in the manufacture of almost every familiar type of direct current ammeter and it is entirely feasible to apply it to other cases than in the manufacture of these instruments. For ordinary cases where small errors are admissible the multiplying factor is merely the reciprocal of the resistance. If we connect a voltmeter, as in Fig. 1, to the terminals of a

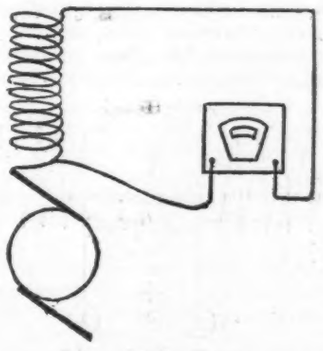

Fig. 1.

resistance, the series coil of a dynamo, for example, the current flowing is equal to the potential indicated by the voltmeter divided by the resistance of the series coil, in accordance with Ohm's law. This assumes that the current taken by the voltmeter is a negligible amount, and with a good instrument its resistance is so great that even when its needle is

fully deflected this may be assumed to be the case. It will at once be seen that it is necessary to know the resistance of the coil in order that the calculation may be complete. If the measurements are not to be strictly accurate and the conditions will not be objectionably affected, a length of wire of known gauge may be inserted and used as the resistance. The numerical resistance of the wire is then only a matter of a few minutes' calculation with the aid of a wire table, which every electrician employed on such work should carry. It may be the case that an ammeter is at hand, but of too limited range to measure the output required. It will then be an easy matter to reduce the current to the limits of the instrument, and by taking a deflection at the terminals of the series coil or other resistance it is proposed to measure with the aid of a voltmeter the value in ohms may be determined by dividing the voltmeter reading by that of the ammeter.

In any event the voltmeter may be connected around the resistance and its readings recorded and the resistance measured at leisure, or when accurate instruments are available. The initial readings of the voltmeter may then be readily translated.

It is important that the resistance, if it be an inserted one, be of sufficient carrying capacity to carry the current without overheating.

The scale of the voltmeter should be as low as possible. The reason for this lies in the fact that low resistances are most readily available as a usual thing, and the volt's drop through them is very small, and therefore can be measured accurately only by a low reading voltmeter.

In railway power stations the portable voltmeter at hand is usually of 500 volts scale, but often has a 5-volt scale for use in calibrating. This 5-volt scale is eminently suited for such measurements as those just described. In case the voltmeter has no low reading scale one may be provided at the expense of a little calculation, a little labor and a few cents' expenditure.

Most voltmeters consist of a sensitive mechanism in series with a large resistance, as shown in Fig. 2. A few volts, or often a fraction of a

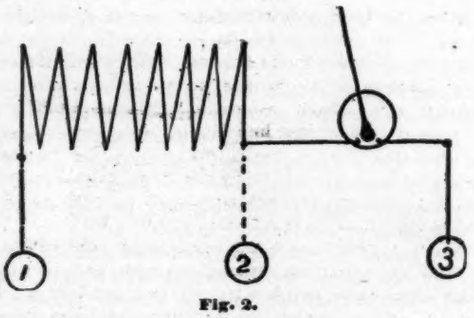

Fig. 2.

volt applied to the terminals of the mechanism alone would deflect it clear across the scale. The larger portion of the voltage applied to the terminals of a voltmeter is used in forcing the current through this enormous dead resistance in its construction. A mere fraction of the total voltage suffices to force the deflecting current through the mechanism. Therefore, to obtain a low-reading instrument, open the voltmeter and attach a light wire to the circuit, as shown, and bring it out to neat binding post on the casing of the instrument, as shown by the dotted line. Some voltmeters have their resistances connected as in Fig. 3, and in that case two auxiliary wires will be necessary as shown.

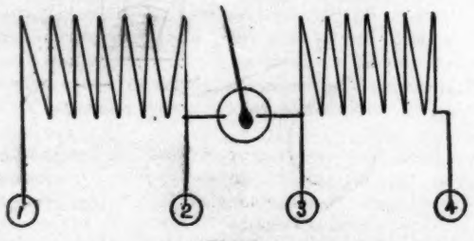

Fig. 3.

In the first case, 2 and 3 will be the terminals of the low reading voltmeter. In the second case, binding posts 3 and 4 would be used. It must be borne in mind that by attaching these terminals to any voltage greater than that which will deflect the needle fully across the scale the coil will be burned out. It is therefore necessary to proceed very carefully in determining what this voltage may be. It is as yet an unknown quantity, and the pressure of an ordinary sal-ammoniac cell if applied to these terminals may ruin the instrument.

Having neatly made the connections as indicated, take the instrument to some good testing laboratory and accurately measure the resistance between the binding posts 2 and 3, or in the second case, 3 and 4. The total resistance of the voltmeter is usually given, especially in the better makes of instruments, but if it is not, this must also be measured. It will pay to make these measurements with extreme accuracy, for after their completion you will have increased the utility of your voltmeter fully 50 per cent.

The multiplying factor to give true volts is now to be calculated as follows: Divide the resistance of the separated mechanism by the resistance of the voltmeter and obtain a multiplier, which, when multiplied into the voltmeter reading, gives the true volts at the terminals of its separated mechanism.

Taking a practical example, suppose the resistance of the voltmeter to be 5,000 ohms and the resistance of the mechanism to be 45 ohms, the multiplier would then be $\frac{45}{5000} = .009$. Then if we connected the voltmeter by means of the circuit provided by the new binding posts and obtained a deflection reading 550, the true volts at the terminals would be $550 \times .009 = 4.95$ volts. It is obvious that the factor .01 would be much better for calculation purposes than .009. If it is desired to obtain this it can be done by unwinding a proper portion of the main resistance and connecting, as shown in Fig. 3, provided that the resistance of the mechanism is less than $\frac{1}{100}$ of that of the entire instrument. This is a matter of some delicate manipulation, and it should not be attempted unless the operator is skilled. The factor obtained by direct connection is just as accurate though less convenient. This change may be easily accomplished without breaking the seals which guard the mechanism.

The measurements which have been described thus far assume the voltmeter current to be negligible relatively to the current measured, and as the maximum current of a good voltmeter is not more than $\frac{1}{10}$ of an ampere, this is almost always the case in railway work. However, in the measurement of leakage currents, the calibration of instruments or in electrical investigation, this factor cannot be neglected, and therefore this case is considered.

Assuming as before that we have a known resistance through which an unknown current is flowing, it is evident that if we connect the voltmeter to the terminals thereof a portion of the current will be deflected through the voltmeter circuit, and the current through the main circuit which now divides through the voltmeter and the known resistance will be increased. If we consider that the known resistance and the voltmeter together constitute one instrument, we desire the value of the current feeding the two parts, and, therefore, the sum of the voltmeter and resistance currents. If R represents the value of the external resistance, and R the resistance of the low-reading votmeter, then by the law of dividend flow the combined resistance would be—

$$\frac{R R_1}{R + R_1}$$

As the voltmeter indicates the true voltage across the terminals of the combination, the current would be—

$$C = \frac{(R + R_1) V}{R R_1} \qquad (1)$$

where V is the voltage of the terminals. By choosing the value of the resistance R, Fig. 1, we can make the voltmeter deflection as great or as little as we please, and by properly proportioning it we can make the voltmeter read amperes directly without calculation or by the use of an easy factor of transformation. It is very desirable to have this resistance as low as possible, and this to a certain extent limits our choice. As a good voltmeter should have a high resistance, so a good ammeter should have a low resistance, and we must not depart from these conditions in shunting our voltmeter for ammeter purposes. When we are using for a resistance some part of the actual circuit this condition does not limit us, but when we insert a resistance in series for this purpose it must be small in order first not to disturb the initial conditions, and second, not to absorb too much energy.

Consider the case of a 500-volt instrument with a calibrating scale of 5 volts. Suppose that we wish to have the instrument read amperes directly on its 500-volt scale, using the 5-volt terminals in multiple with a resistance. What must this resistance be? Then our assumption demands that for every volt which the instrument indicates on its 5-volt scale 100 amperes shall pass through the system. We therefore have the condition that $100 v = C$, and if the 5-volt coil of the voltmeter has a resistance of, say, 45 ohms, equation (1) becomes—

$$100\,v = \frac{V\,(R + 45)}{45\,R}$$

Whence— $$R = \frac{45}{4{,}499} = .010002$$

Had we neglected the resistance of the voltmeter we would have obtained R from simply $R = \frac{V}{C}$

$$R = \frac{E}{1{,}002} = .01 \text{ ohm},$$

and the difference is in this case negligible. Hence, for ordinary work with a voltmeter of sufficient resistance to be a commercial instrument, no allowance for its resistance is necessary.

The resistance of .01 of an ohm is rather high for an ammeter, but were it used on circuits where dead resistance is inserted, *e. g.*, field circuits, this would not be an objection. Unfortunately, if we attempt to reduce the resistance of this instrument, the range is increased and the disproportionality of the two is still maintained. The only possible way to correct this would be to employ a voltmeter with a lower scale. Good voltmeters do not need a large voltage to deflect the mechanism across the scale. In most cases the merest fraction of a volt will suffice. Therefore, when the instrument is provided with a special binding post as previously indicated, a very good ammeter, suitable for any purpose in its range, can be constructed by this method of shunting. However, when the mechanism alone is brought out to binding posts, the resulting scale requires an odd multiplying factor to get true volts, and this factor must be multiplied into the equation of condition as well. Suppose, for instance, in the case of this same voltmeter, that the factor is .0007, *i. e.*, the voltmeter reading must be multiplied by .0007 to get true volts. If we desire the scale to read directly the equation of condition would be—

$$C = \frac{1}{.0007}\,v = 1{,}428.5\,V,$$

and making this substitution the procedure is the same as before.

It is sometimes necessary in laboratory practice to draw a very small current from a power circuit. This occasionally occurs in some railway testing, and to render this article more complete, the following method is given :

In such a case where the current is very small and the voltage relatively high, an ammeter of high resistance is not only unobjectionable, but is a decided advantage, provided the working portion of the circuit is of low resistance. Suppose the case of a voltmeter with a scale of 500 volts and a resistance of 10,000 ohms. If this be connected in series with any device across the 500-volt mains, the current flowing is equal to the voltage indication divided by the resistance of the instrument. Such an instrument as the one described can be read directly within 5 volts, and by estimating to within ½ a volt. If, therefore, in this instance the reading was 475.5, the current would be .04755 ampere, measuring the current with far more accuracy than any but the best mil-ammeters. The great resistance which is often objectionable in such cases as these is no hindrance.

The Roentgen Rays.

[By President Henry Morton, Ph. D., Stevens Institute of Technology, in *Engineering*.]

In connection with Dr. Roentgen's discovery and the X rays there are a number of facts long known which in some cases seem to be forgotten, and which, while in no way detracting from the originality and merit of his discovery, yet need to be considered in order that the true characteristics of this discovery should be recognised, and the mixed or uncertain character of many experiments recently made by others in attempting to repeat or extend his results, clearly appreciated. Thus, to begin with, it is not new that invisible radiations obtained by electrical discharges in Geissler tubes and elsewhere should produce photographic and fluorescent effects.

In the *American Journal of Art and Science*, 1864, vol. xxxvii., page 207, will be found a paper by Professor O. N. Rood, of Columbia College, entitled "On the Action of very Weak Electric Light on the Iodised Plate." From this paper I will make a few quotations :

"About three years ago Dove received from Mr. Gunther, of Berlin, a photograph of a bronze statue of an amazon holding a lance in a perpendicular position, Mr. Gunther at the same time calling his attention to a singular mark in the picture, which was not in the original.

"The lance was properly delineated on the negative plate, but in addition, just at the tip, a dark streak was visible, though nothing of the kind had been observed at the time of taking the picture. Careful examination of the plate showed two other analogous marks. Dove thought that these singular appearances might have been caused by the presence of invisible electric brushes, resting on these points, and undertook some experiments to determine whether weak electric light could be photographed. Geissler tubes were used in a dark room, and with the aid of Gunther he succeeded in obtaining good photographs of the stratified discharge."

Professor Rood then goes on to describe further experiments of his own made to ascertain if these faint electric lights or discharges could be photographed in a light room, and when they were invisible to the eye. After describing some preliminary trials he further says : "Accordingly, to make an exact experiment on this point, a sheet of white paper was placed behind one of these [Geissler] tubes and white light reflected through it towards the camera. The intensity of this reflection was so regulated that the bright envelope of the platinum wire [in the tube] was nearly invisible, and the diffused violet light at a greater distance from the wire absolutely invisible. Nevertheless an intense photographic image of the envelope, and a very distinct image of the diffused electric light, was easily obtained, thus proving conclusively the correctness of Dove's assumption, that electric light, which in ordinary daylight could not be seen, owing to its feeble illuminating power, might yet make itself very evident on the iodised plate, by virtue of its high percentage of chemical rays."

The above is interesting as showing that as early as 1864 the relatively greater photographic than visual effect of the light produced in exhausted tubes (Geissler tubes) was recognised.

About the same time and thereafter, and, indeed, up to the present day, much work was done in photographing that part of the solar spectrum which represents those vibrations which, by reason of their short wave-length, have either little effect upon the eye or none at all.

Professor William A. Miller,[1] in London, carried this work far enough to show that he could, by the use of quartz lenses and prisms, secure a photographic spectrum from the electric light extending beyond the visible violet for a distance several times as great as separated the extreme violet from the lowest visible red, at the other end of the visible spectrum. It was thus shown that invisible radiations of short wave-length possessed remarkable photographic power.

I will now turn to another line of observation which marks a limitation or distinction of the Roentgen effects in another direction. When the eye is directed towards a faintly luminous object, it will either at once perceive it (under favorable conditions), or not at all. In other words, nothing will be gained by continually gazing at it. On the contrary, the best chance of catching sight of a faint object, such as a feebly luminous comet, is to look away from the true direction, and then, with some quickness, to turn the eyes towards it. In this way we can often secure a momentary impression of a dim object which we cannot perceive continuously. With the sensitive photographic plate, however, all this is reversed.

An amount of light which, acting on a plate for 1 second, produces no sensible impression, will produce a strong one if its action is continued for 20 or 30 seconds, and so on up to several hours of exposure.

One of the most interesting illustrations of this has been furnished in connection with the photographing of stars carried on at the Harvard Observatory under the Henry Draper Memorial, maintained by Mrs. Henry Draper, of New York; but the first observation of this phenomenon was made by Mr. A. A. Common in connection with his beautiful photograph of the nebula in Orion. (See Astron. Soc. Month. Not. 43, 1883, page 255.)

It was there found that besides the impressions of visible stars on plates exposed for a long time, there were many other similar spots or images occurring time after time in the same positions on successive plates, which were due to stars too faint to be perceived by the eye, but yet capable, by prolonged action, of producing images on the sensitive plates.

We see, then, that the photographic plate has yet another means of seeing in the dark, besides that due to its power of perceiving vibrations whose wave length is too short to affect the nerves of the retina. By its accumulative action, or capacity of storing up the effects of any sort of vibrations capable of affecting it, rays too feeble to affect the eye will, in time, impress the sensitive film. There is yet another region of observation which should be marked off, in order to appreciate fully the nature of the Roentgen discovery.

When in August of 1880, D. A. G. Bell announced his remarkable invention of the photophone, by means of which sounds and articulate

1 See Philosophical Transactions of Royal Society, 1862.

speech could be conveyed from one place to another by a pencil of light, he stated at the same time that the radiant vibrations of sunlight by which this result was secured were only to a moderate extent impeded by a sheet of hard rubber thick enough to shut out to the eye every trace of light even from the concentrated rays of the sun. It had also been noticed some time ago by others that a sheet of hard rubber was not a perfect shield for a sensitive plate if there was any considerable exposure to sunlight. (See also "Photography of the Infra-Red Region of the Solar Spectrum," W. H. Pickering, Ph.D., 1884, Pro. Am. Acad. of Arts and Sciences.) Moreover, Carey Lea, of Philadelphia, more than 25 years ago, had shown that a negative plate could be so acted upon as to develop an image on applying the usual developer, by the application of very moderate heat, and even of slight mechanical pressure. (See his "Manual of Photography," second edition, 1871, p. 408.) This last is of special interest in connection with Tesla's recent suggestion that the Roentgen pictures may be due to the mechanical action of the impact of particles actually driven at high velocities from the cathode pole. While the above facts detract nothing from the originality and merit of Dr. Roentgen's real discovery, they are of use in helping us to appreciate what is its important and central characteristic, and to discriminate between the same and many of the so-called repetitions and extensions of his work with which the daily papers have been filled.

The Roentgen discovery differs from all that went before, not in the broad fact that some sorts of radiation would act on sensitive plates when, by passing through certain screens or otherwise, they had become, or were, invisible, but in that this investigator has shown a new sort of vibrations absolutely devoid of luminous properties, and yet capable of easily penetrating certain materials of the greatest optical opacity, such as black paper. The experimenters who have been producing shadow photographs with sunlight, electric lights, and the like, have not been repeating Roentgen's operations, but only applying facts known for 15 or more years.

There is another part of Roentgen's work which, though followed up by some, has as yet excited much less general attention, partly, no doubt, because the materials and conditions for making experiments are less easy to secure, and also because the results are not permanent, but must be inspected while they are being produced; I allude to the developments of fluorescence and the production of shadow pictures visible on a fluorescent screen.

To make this subject clear, and as before to bring out the exact novelty of Roentgen's work in this connection also, I must go into the early history of the subject of fluorescence. This was first systematically studied by Professor Stokes, of Cambridge, England, and admirably developed in his classical paper in the Philosophical Transactions for 1852, Part 2, page 466 *et seq.* In this place he shows that quite a number of solid bodies and solutions possess the power of absorbing light vibrations of various wave lengths and then instantly emitting them again, but always with an increase of wave length. Thus, for example, a solution of acid sulphate of quinine will absorb the extreme violet rays of the spectrum and then emit them as bright blue rays. Again, an alcoholic solution of chlorophyll (the coloring matter of plants) will absorb yellow rays, as well as shorter ones, and emit red light. There are many other bodies acting on and producing different rays, but in every case the emitted ray is of greater wave length, or, as we say, lower in the spectrum than the absorbed or exciting ray.

As might naturally be expected on this principle, the extremely short wave lengths of rays above the visible violet of the spectrum causes them to be absorbed by most fluorescent bodies, and emitted as rays of greater wave length and therefore visible, and thus in this way also was supplied a method of making invisible light of solar vibrations visible. In fact, Stokes showed that if a solar spectrum was thrown on a block of "canary glass" (glass colored greenish yellow by oxide of uranium), its upper end was elongated or rendered visible by the fluorescent light developed, just as it was similarly extended upwards when photographed upon a sensitive plate. Besides canary glass many other materials could be used, the most efficient being a sheet of paper coated with a paint made from finely pulverized crystals of the platinocyanide of barium. This subject was further investigated in this special relation by Stokes, and also by Miller in 1862 (see Phil. Trans. 1862).

In 1872 the present writer had the good fortune to discover in, and extract from, certain dense and tarry petroleum distillates, a hydrocarbon to which he gave the name thallene, which possessed this property of fluorescence in a pre-eminent degree. Itself of a light lemon yellow color, if spread as a pigment on paper, it shines out with a flood of grass green light when placed in the invisible part of the spectrum, or when there fell upon it violet or blue light. Its peculiar properties were exhibited at a lecture on fluorescence, delivered in the Academy of Music in Philadelphia in 1872, in the following manner: A screen or curtain of muslin of the yellow color of thallene was prepared of about 20 feet square, and to this was attached a design of leaves, wreaths, etc., made of paper coated with thallene. Seen by gas light this design could not even be recognized at a short distance, but when the rays of a powerful electric light, sifted through a dark purple glass, which cut off all but the violet and super-violet radiations, were thrown on it, the design fairly blazed out in vivid green on a background of muslin, which looked as dark as black velvet. The yellow muslin could not reflect any of even the violet light, but the thallene turned this, as well as the super-violet invisible rays, into vivid green. A full account of this material will be found, among other publications, in the *Chemical News*, of London, 1872, vol. xxvi., page 272; the *London and Edinburgh Philosophical Magazine*, 1873, vol. xlvi., page 89, and the *American Chemist*, 1873, vol. iii., pages 81 and 162.

The general subject of "fluorescence" is also discussed at some length by the present writer in the article under this heading in Johnson's "American Encyclopedia."

Here, then, we see that prior to Roentgen's experiments it was well known that certain practically invisible rays could produce visible effects through the action of "fluorescence." What Roentgen has added to this is the knowledge that such rays are developed in peculiar abundance in the highly exhausted tubes known as "Crookes tubes," and that they will penetrate with unexpected facility a great many optically opaque substances. Just what is the distinguishing character of these peculiarly actinic and fluorescogenic rays is at present a problem enshrouded in great obscurity, by reason of the conflicting statements of experimenters. Roentgen and others say that they proceed from the cathode terminal. Professor Rowland and others say that they come from the anode. Tesla thinks that they are not vibrations of any sort, but are streams of projected material particles.

It would seem that the judicious course is to build no theories, but to extend experiments and accumulate facts. This is being done by various able and experienced investigators who have not been in haste to publish the incomplete results of their work. Among these we would mention Professor O. N. Rood, of Columbia College, New York, and Professor A. M. Mayer, of the Stevens Institute of Technology, New Jersey. Among their interesting results is an absolute demonstration that the X rays are incapable of polarization. This property was indicated by Professor Roentgen in his original publication, though not fully established, and is of great importance as radically distinguishing the new radiation from any known variety of heat, light, or actinic vibrations.

ITEMS OF INTEREST FROM VARIOUS LOCALITIES.

THE following circular explains itself:

TEXAS GAS AND ELECTRIC LIGHT ASSOCIATION,
OFFICE OF THE SECRETARY, GONZALES, TEX., April 22, 1896.

The Oriental Hotel has been chosen as headquarters for our Association, and the meeting will be called to order at 10 o'clock, Tuesday, May 12th. It is expected that the Executive Committee and the Finance Committee will meet in the hotel parlor, Monday, May 11th, to act on matters brought before them.

The Committee of Arrangements have arranged for special excursion rates to McAllister, Krebs and other Territory coal mining points. The fare to members of the Association will be one cent per mile ($3.33 for round trip) from Dallas to McAllister and return. Add $2 each way if you take sleeper. If you contemplate joining this excursion write Mr. Thomas D. Miller, care Dallas, Texas, so letter will reach him not later than May 8th, and if he has notice that as many as 15 will go (we will probably be nearer 30 strong), he will secure a special Wagner sleeper which will be at our disposal from the time we leave Dallas until we return. Expense, same as above.

Our present plan is to leave Dallas, via "Katy," about 9:30 P.M. of May 12th, reach South McAllister 5:30 A.M., 14th, where Mr. Dow will have a special car to take us to the Choctaw mines. Returning to South McAllister, we will visit the McAllister and other mines, and again returning to South McAllister, will take train for Dallas, which we will reach about 7:30 A.M. of 15th, in time to take all outgoing trains for home.

To non-members we would say that our Association is neither a gas nor electric man's Association, but an Association of the Texas lighting men and their friends. So, if you are an electric man, don't hold back, thinking it is a gas man's meeting; and if you are a gas man don't

hold back, thinking it is an electric man's meeting. We are lighting men, and we want every lighting company in the State to be represented at our meeting. It will pay you individually, and it will pay your company.—HOMER W. STARR, Secretary.

THROUGH inadvertence we failed to note that the paper on "The Practical Use in the Chemical Laboratory of the Electric Arc Obtained from the Low Potential Alternating Current," by Mr. Milo S. Walker, which was printed in our issue for April 20th, originally appeared in the *American Chemical Journal*.

MR. CHARLES A. LEARNED took charge of the plant of the Meriden (Conn.) Gas and Electric Light Company on the 1st inst. Mr. Learned, who is a brother of Mr. Waldo A. Learned, Supt. of the Newton and Watertown (Mass.) Gas Light Company, was formerly with the United Gas Improvement Company, under Mr. Rusby, at Jersey City, N. J.

THE union of the San Francisco Gas Light Company and the Edison Light and Power Company, of the same city, has been to all intent and purpose consummated.

AT the annual meeting of the Freeport (Ills.) Light and Fuel Company the officers chosen were: Directors, Jacob Krohn, Wm. D. Wright, G. B. Bidwell, C. D. Knowlton, L. L. Munn, T. K. Best and J. L. Robinson; President, C. D. Knowlton; Vice-President, Jacob Krohn; Treasurer, Wm. O. Wright; Secretary and Manager, Z. T. F. Runner.

THE proprietors of the Ann Arbor (Mich.) Gas Company have instituted the following selling rate schedule, which took effect on the 1st inst.: Gas used for illumination, $1.70 per 1,000 gross, the following discounts to rule on amounts of gas used each month, conditioned on payment of bills on or before the 15th of the month: Less than 1,000 cubic feet, 10 cents; bills of 1,000 to 5,000 cubic feet, 20 cents per 1,000; bills over 5,000 cubic feet, 30 cents per 1,000. Gas used for fuel purposes: On all quantities, $1.25 per 1,000 gross; $1 per 1,000 net.

WE understand that the proprietors of the Meridian (Miss.) Gas Light Company have leased their electric plant to Mr. W. R. Hall, General Manager of the Meridian Street Railway Company, the lease to run for 10 years, from May 1st.

AT the annual meeting of the Bridgeport (Conn.) Gas Light Company the shareholders were well pleased over the condition of the Company's affairs, as shown by the official reports for the past twelvemonth. The officers chosen were: Directors, Wm. R. Higby, Samuel C. Trubee, H. L. Clark, W. B. Hincks, W. D. Bishop, Wm. H. Perry, Alfred Hobbs and E. G. Burnham; President, W. R. Higby; Secretary and Treasurer, F. B. Sammis.

MR. HORACE H. SWAN has been reappointed Superintendent of the Westerly (R. I.) Gas and Electric Light Company.

A CORRESPONDENT forwards the following budget, under date of April 25th: "The St. Paul (Minn.) Gas Light Company will move into new and commodious office quarters on May 1st.——The Key City Gas Company, of Dubuque, Iowa, will also, on May 1st, move from a limited and cramped office to a spacious store on the principal business street of the city. The new offices include a spacious display room for stoves and improved lamps and burners.——Everyone who attends the meeting of the Western Association this year will be certain to appreciate the magnificence of the Lookout Inn. The rates have been materially reduced; but the services will be first-class in every respect.——Members resident in the North can take a train, leaving Toledo, Ohio, at midnight, on the Cincinnati, Hamilton & Dayton Road, reaching Cincinnati in ample time to have breakfast and make connections with "Ed." H. Jenkins' special train, direct to Lookout Inn. The special will be very desirable, for the daylight ride over the mountains is nothing short of grand."

AT a recent meeting of the Directors of the Carlisle (Pa.) Gas and Water Company a semi-annual dividend of 3 per cent. was declared. It was also determined to abolish the practice of charging a meter rental.

THE Baltimore (Md.) County Commissioners have issued a permit to the Consolidated Gas Company to lay its mains in the outlying district of Catonsville.

THE Delaware (O.) Gas Company issued a large number of invitations to the residents to call at the Company's offices, on the afternoon of April 23d and 24th, for the purpose of inspecting a handsome and up-to-date assortment of gas cookers, heaters, improved gas burners and fixtures, etc. The visitors were representative and many, and the interest shown by them was sufficiently practical to enable the Company to book orders in plenty for the wares that were shown. Caterer Jackson served a well-arranged luncheon, and Bandmaster Lindsey's orchestra discoursed sweet music while the visitors inspected or lunched. Mr. T. Clive Jones, the Company's clever Superintendent, was here, there and everywhere during the times of the exhibition.

THE Committee on Corporations of the Rhode Island Legislature having assented to the bill for an Act to amend the Act incorporating the Warren Gas Light Company, which provides for the consolidation of the gas and electric light companies of Warren and Bristol, the same was passed by the General Assembly.

IT is said that a hitch has occurred in the negotiations under which the Gray syndicate was to acquire possession of the properties of the Norristown (Pa.) Gas Company. The syndicate, however, has until the 15th inst. to complete the purchase.

MR. WARREN STICKLES has been appointed Superintendent of the Rhinebeck (N. Y.) Gas Company.

THE death of Mr. Henry F. Hills, one of the founders of the Amherst (Mass.) Gas Company, occurred at his home in Amherst, on the morning of April 25th. He was in his 63d year, and had been prominent for half a century in Massachusetts business circles.

THERE is every probability that the Manufacturers Gas Light Company, of Fall River, Mass., and the Fall River Gas Company, will shortly agree upon a plan for an amalgamation of their interests and trade.

THE Keystone Meter Company, of Royersford, Pa., informs us that it will be pleased to mail its gas stove catalogue to all who ask for it.

A CORRESPONDENT at Louisville, Ky., writing under date of April 25th, says: "Mr. Addison Harris, acting as attorney for the New Albany (Ind.) Gas Light and Coke Company, will institute suit in the Federal Court, Indianapolis, against the city of New Albany, to recover nearly $10,000 for the service of a number of street lamps in the business portion of that city, abandoned several years ago by order of the Common Council, during the administration of the late Hon. Morris McDonald as Mayor, the lamps having been dismantled and the streets lighted by electricity furnished by another Company. The Gas Company claimed that a contract exists with the city for lighting the streets at a fixed figure for each lamp per annum, and that the amount sought to be recovered is due and unpaid. Only a few days ago the New Albany Council authorized the Mayor and the Committee on Contracts to contract with the Light, Heat and Power Company for lighting four of the principal streets of the city by means of electric arc lights, thereby cutting off the Gas Company from the greater portion of its revenue from the city, and this suit will be brought as much to test the validity of the contract, entered into years ago, by the decision of the Federal Court, as to recover the money alleged to be due."

ON the 22d of April, Judge Foster, in the Superior Court, decided the suit of John J. Nolan against the City of Evansville, Ind., and the Evansville Board of Public Works, in favor of the city. "This suit," says the Evansville *Courier*, "arose out of the lighting contracts which were let to the Evansville Gas and Electric Light Company, the Peoples Electric Light Company being the opposing bidder, for lighting the city for a 5-year contract in 1895. Bids were advertised for some time in March, 1895. The Peoples Electric Light Company, at the time of the advertisement, gave out the opinion that it could not bid, but at the last moment presented a bid. Its bid was for 400 arc lights, according to the advertisement, which it offered to maintain for 5 years at $119 per year per light. The Gas Company, however, put in a bid, ignoring the fact that the advertisements called for 400 arc lights, offering to maintain 250 gas and 250 electric lights—the arcs at $95 and the gas lights at $20 each per year. The Board of Public Works considered the bids and accepted those of the Gas Company, although they were not according to the specifications. Shortly after the letting of the contract, Mr. J. J. Nolan, Secretary and Treasurer of the Peoples Electric Light Company, filed a complaint restraining the city from giving the contract to the Gas Company—Mr. Nolan filed this complaint as a private citizen and taxpayer and not as an official of the Peoples Electric Light Company. In his complaint he stated that the Gas Company bids had

been accepted, regardless of the fact that the law requires that advertisements be published three months before the letting of contracts, while no advertisements had appeared regarding gas street lamps. The city filed an answer to the charges of Mr. Nolan, stating that while no advertisement appeared for the gas lights, it was believed the service of the Gas Company would be better and cheaper than that of the Electric Company. The answer stated also that the named Gas and Electric Companies were the only corporations able to furnish lights by reason of being the only Companies in the city having plants. Further, the city made several points showing the relation sustained by Mr. Nolan to the opposition Company. The following is the substance of Judge Foster's decision:

"The Board of Public Works adopted specifications and gave notice that they would receive proposals for lighting the city with about 400 electric arc lights. The Peoples Electric Light and Power Company filed a bid in all respects in accordance with the notice and specifications at $119.43 per light. The Evansville Gas and Electric Light Company only bid on 250 electric lights, at $95 per light, and included in its bid a proposal to furnish in addition 250 gas lamps at $20 per lamp. Two separate contracts were made between the Evansville Gas Company and the Board of Public Works, both of which were ratified by the Common Council. The action is brought by the plaintiff as a taxpayer to declare the contracts void. The charter of the city provides that whenever a contract for lighting the city is to be let, the Board of Public Works shall give notice that they will receive proposals therefor at least three months before the expiration of the then pending contract. Plaintiff claims that the bid of the Evansville Gas Company, not being in accordance with the notice given by the Board of Public Works, had no power to consider it. That no contract could be legally awarded upon it, and that the Board of Public Works were either compelled to accept the bid of the Peoples Company, or reject the bids and readvertise. Judge Foster holds that while the giving of the notice required by the act referred to is a condition precedent to the power of the Board of Public Works to contract in the sense that the Board can only contract in strict accordance with the terms they have sent out in the notice, and that they are not compelled to disregard a bid merely because it is not in accordance with the notice, that the statute cannot be construed as requiring a readvertisement in the event the bids are unsatistactory for the reason that after one notice has been given it is impossible to comply with the requirements of the act that the notice should be given three months before the expiration of the pending contracts. And if the Courts were to construe the language of the act to mean three months before the expiration of the old, and this construction were now given to it, it would leave the city without power to contract for the lighting of its streets and public places during the three or four months necessary to give the notice and award the contract, a construction which could not have been intended by the Legislature. The Court, therefore, holds that the answer of the city alleging that the notice was given as required by the act, and that the bid of the Evansville Gas and Electric Light Company was much lower and better for the city than that of the Peoples Electric Light Company, is sufficient to constitute a good answer to the complaint."

REPEATED and voluminous inquiry for the stock of the Newark (N.J.) Gas Company has caused the local newspapers to suggest that outsiders are anxious to secure control of that valuable and well-managed property. The only real thing which the inquiry reveals is that careful investors are alive to the possibilities that an investment of the kind under consideration carries.

A VERY well-arranged circular is that prepared by the proprietors of the Ann Arbor (Mich.) Gas Company, showing the advantages of gas for cooking, especially when the rate on gas for such purpose is only $1 per 1,000. The circular is appended—the memorandum book which is distributed with the text is quite a neat affair:

ANN ARBOR GAS COMPANY,
ANN ARBOR, MICH., April 20, 1896.

Dear Madam:—In handing you this little memorandum book we want to call your attention to the fact that after May 1st we are going to sell gas for fuel purposes for $1 per thousand.

The hot weather is now coming on, and you are all, no doubt, thinking how you can make your kitchen cooler and your work easier. This cannot be accomplished in any easier way than by getting a gas stove.

To begin with, you can buy a gas stove 20 per cent. cheaper than any other stove—wood, coal or gasoline—of the same capacity. Then after you get it you do not have to get up an hour earlier every morning to get a fire started. You strike a match and the gas does the rest. If you are not baking you do not have to heat up your oven; you can use just what burners you need for your work.

There is not a lot of hot iron to heat up your kitchen; everything is cool, clean and comfortable. Repairs or attention won't cost you a cent. We do that free.

Some of your neighbors probably have stoves, as there are over 400 families using gas for cooking in this city. Go ask them how they like it, and then come down and look over the complete assortment of stoves, ranges and all gas appliances, which we have at our office.

Yours, ANN ARBOR GAS COMPANY.

Methods of Closing Cracks in Cast Iron.

Many methods for closing cracks or pores in cast iron have been devised, according to *Industries and Iron*. Chemical or other products, such as sal-ammoniac or urine, are often used to cause the formation of an iron salt, easily oxidizable, which in a short time gives a certain quantity of hydrated oxide of iron. This is made use of very often to stop up leaks which develop in metallic cylinders. This method is, however, a somewhat lengthy one, several days being oftentimes necessary to obtain satisfactory results; that is to say, entire absence from leakage. A method of closing cracks or pores in a more rapid and certain manner has lately been devised by M. A. Demalght, of Brussels. The method is described as follows: The cylinder is filled with a certain quantity of perchloride of iron. The liquid is then compressed until globules appear on the external surface. The cylinder is then impregnated with perchloride of iron right through, as regards its thickness. Any perchloride in the cylinder is then emptied out, the cylinder being then wiped until the polished surface is again made brilliant. It is then filled with ammonia at 22° Baume, this also being subjected to compression. The effect of this operation is soon noticeable, the perchloride of iron in the metal becomes transformed under the influence of the ammonia into hydrated oxide of iron, at first somewhat frothy in character, and afterward, under the influence of the external pressure, rough and compact. Some hydrochlorate of ammonia also remains, which will soon afterward react on the iron, which will eventually be converted into an oxide compound, adding itself to the first. The leaks marked at the commencement of the operation will be entirely stopped as soon as the ammonia commences to move out externally, the whole operation not occupying more than a couple of hours. One advantage of the new process is that leaks are stopped by an independent injection of hydrate of iron, while in the many processes at present in use the result is obtained at the expense of the iron in the cylinder, that is to say, one part has to lose that which another portion gains.

The Market for Gas Securities.

Well, the Legislature has adjourned, and, as we said several weeks ago would be the case, no change was made in the gas rates for New York and Brooklyn. Under the operation of this knowledge, prices for New York city gas shares have been fairly well maintained, particularly in respect of Consolidated, which, during the week, made a new record for itself—a maximum price of 164¼. To-day (Friday) an easier feeling prevailed in it, the reaction undoubtedly being attributable to realizing sales, and a rather panicky general market.

Rumor now has it that the Consolidated management will declare this quarter an extra dividend, but we do not share in the idea that such a disbursement will be made, although it is beyond doubt that the Company could easily add a sensible sum to its dividends from its profits. The closing sale to-day in Consolidated was 100 shares at 162½, and the bid price at the last call was 162½, offered at 163. The shares are cheap. Mutual is 235 bid, with no stock offering, and Equitable is also in demand at 213 to 218. The common of New York and East River is inquired for at 39, and Standard common is steady, at 77 to 79.

The main interest, however, in the local gas share market centered in Brooklyn Union, which, on persistent inquiry, advanced in most pronounced fashion. To-day it is quoted at 95½, offered at 96. An odd lot was sold at auction during the week at 95. There is very little doubt that a substantial dividend on it will be shortly declared, probably at the rate of 5 per cent. per annum. The announcement of the meeting to completely form the executive management of the Company may be looked for at any time, and it is on the cards that the staff will be about like this: President, Gen. J. Jourdan; Vice-President, (?); Secretary, W. H. Rossiter; Treasurer, Mr. Chapman; Gen'l Manager, C. H. Stoddard; Managing Engineer, Col. Fred. S. Benson.

Out-of-town shares are fairly steady, notably Newark (N. J.) gas, which is in good demand at par. Chicago is quite even, with a tendency to higher figures, and Consumers, of Jersey City, is said to be offered at 81 ex-div., which is certainly cheap for it.

Gas Stocks.

Quotations by Cochran & Close, Brokers and Dealers in Gas Stocks.

35 Wall St., New York City.

May 4.

☞ All communications will receive particular attention.

☞ The following quotations are based on the par value of $100 per share.

N. Y. City Companies.	*Capital.*	*Par.*	*Bid.*	*Asked.*
Consolidated	$35,430,000	100	163½	164¼
Central	500,000	50	150	..
" Scrip	220,000	..	100	.
Equitable	4,000,000	100	213	218
Bonds, 6's	1,000,000	1,000	105	..
" 1st Con. 5's	2,300,000	1,000	114	.
Metropolitan Bonds	658,000	..	108	112
Mutual	3,500,000	100	235	..
" Bonds	1,500,000	1,000	100	102
Municipal Bonds	750,000	.	..	.
Northern	150,000	50	79	80½
" Bonds	150,000	1,000	..	98
New York and East River	5,000,000	100	30	35¼
Preferred	2,000,000	100	74½	76½
Bonds 1st 5's	3,500,000	1,000	102½	103
" 1st Con. 5's	1,500,000	..	93½	94
Richmond Co., S. I.	348,650	50	50	..
" Bonds	100,000	1,000	..	..
Standard	5,000,000	100	77½	79
Preferred	5,000,000	100	107	109
Bonds, 1st Mortgage, 5's	1,500,000	1,000	108½	111
Yonkers	299,650	50	130	
Out-of-Town Companies.				
Brooklyn Union	15,000,000	100	95½	96
" " Bonds (5's)	15,000,000	1,000	106	106½
Bay State	5,000,000	50	21	22
" Income Bonds	2,000,000	1,000	..	80
Boston United Gas Co.—				
1st Series S. F. Trust	7,000,000	1,000	78	80
2d " " "	3,000,000	1,000	53½	55½
Buffalo Mutual	750,000	100	125	..
" Bonds	200,000	1,000	95	100
Central, San Francisco	2,000,000	..	95	..
Chicago Gas Co.	35,000,000	100	69¼	70
Chicago Gas Lt. & Coke Co. Guaranteed Gold Bonds	7,650,000	1,000	94	94¼
Columbus	1,069,000	..	..	65
1st Mortgage	1,085,000	..	..	96
Consumers. Jersey City	2,000,000	100	..	81x
" Bonds	600,000	1,000	100	103½x

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Keystone Meter Co., Royersford, Pa.	722
The Hillen Meter Co., Brooklyn, N. Y.	723

PREPAYMENT METERS.

American Meter Co., New York and Philadelphia	723
John J. Griffin & Co., Phila., Pa.	724
D. McDonald & Co., Albany, N. Y.	723

GAS AND WATER PIPES.

Ohio Pipe Co., Columbus, Ohio	721
M. J. Drummond, New York City	721
R. D. Wood & Co., Phila., Pa.	718
Warren Foundry and Machine Co., New York City	721
Donaldson Iron Co., Emaus, Pa.	721
Addyston Pipe and Steel Co., Cincinnati, O.	721

PIPE CUTTERS.

Wm. Anderson, East Boston, Mass.	700

GAS BAGS.

Peerless Rubber Mfg. Co., New York City	700

STEAM BLOWER FOR BURNING BREEZE.

H. E. Parson, New York City	715

GAS COALS.

Penn Gas Coal Co., Phila., Pa.	713
Perkins & Co., New York City	712
Despard Gas Coal Co., Baltimore, Md.	713
Westmoreland Coal Co., Phila., Pa.	713
Berwind-White Coal Mining Co., New York and Phila.	712
Henry C. Scheel, New York City	713

CANNEL COALS.

Perkins & Co., New York City	712
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GAS ENRICHERS.

Standard Oil Co., New York City	713
The Sun Oil Co., Pittsburgh, Pa.	713
W. H. Townsend, New York City	713

COKE CRUSHER.

C. M. Keller, Columbus, Ind.	713

CONVEYING MACHINERY.

C. W. Hunt Company, N. Y. City	701

GAS GAUGES.

The Bristol Co., Waterbury, Conn.	701

GAS GOVERNORS.

Connelly Iron Sponge and Governor Co., New York City.	711
Isbell-Porter Co., New York City	718
The Wilder Mfg. Co., Phila., Pa.	701

SELF-SEALING MOUTHPIECE DOORS.

Isbell-Porter Company, New York City	718
Continental Iron Works, Brooklyn, N. Y.	718
G. Shepard Page's Sons, New York City	719

RETORTS AND FIREBRICK.

J. H. Gautier & Co., Jersey City, N. J.	714
B. Kreischer & Sons, New York City	714
Adam Weber, New York City	714
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Wm. M. Crane & Co., New York City	704

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Greenpoint Chemical Works, Brooklyn, N. Y.	711
Henry W. Douglas, Ann Arbor, Mich.	711

EXHAUSTERS.

The P. H. & F. M. Roots Co., Connersville, Ind.	708
Isbell-Porter Company, New York City	718
Connelly Iron Sponge and Governor Co., New York City	711

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Ludlow Valve Manufacturing Co., Troy, N. Y.	710
Chapman Valve Manufacturing Co., Boston, Mass.	710
R. D. Wood & Co., Phila., Pa.	718
Continental Iron Works, Brooklyn, N. Y.	718
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Isbell-Porter Co., New York City	718
The Western Gas Construction Co., Fort Wayne, Ind.	710

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Wm. Henry White, New York City	719

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Otto Gas Engine Works, Phila., Pa.	684
The American Gas Engine Co., Phila., Pa.	702
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George M. Clark & Co., Chicago, Ills.	705
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William M. Crane & Co., New York City	704
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Davis & Farnum Mfg. Co., Waltham, Mass.	716
Kerr Murray Mfg. Co., Fort Wayne, Ind.	719
Stacey Mfg. Co., Cincinnati, Ohio.	719
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Has been in the employ of the Passaic (N. J.) Gas Company for the last 10 years as Superintendent, and is a practical mechanic, thoroughly understanding the laying out and erection of plants and the making of coal and water gas. Seventeen years' experience as constructor and builder with John Hanlon, Gas Engineer. Best of references. Address
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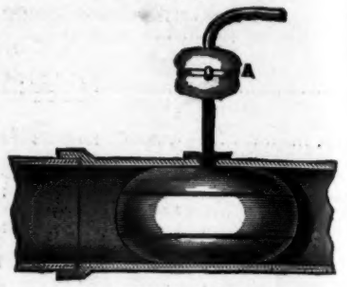

These Gas Bags are used to stop the flow of gas while repairing or making alterations in gas mains. There have been numerous cases of workmen being badly injured, and sometimes fatally, by the escape of gas resulting from the bursting of a bag, and our patent improvement is designed to obviate such calamities. The indicator *A* shows unerringly when the bag has been sufficiently inflated to pack the main, and when the pumping should be stopped. Our Bags are made of a rubber stock especially prepared to admit of great distension, and to resist the action of Oils, Gases, Naphtha and other residuum in the mains, and they are made with lapped joints, which adds greatly to their strength.

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4 "	"	"	.80	16 "	"	"	8.25
5 "	"	"	1.05	20 "	"	"	12.00
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10 "	"	"	3.75				

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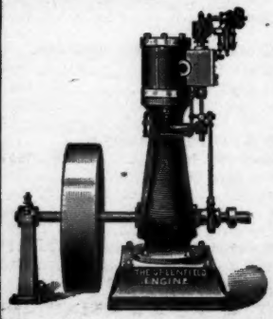

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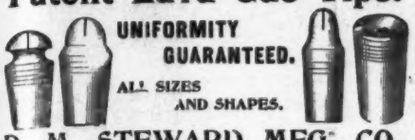

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This Generator is now in use in nearly every State in the Union, and everyone using it will recommend it to you.

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If gas coal is very cheap and anthracite coal and hard coke very expensive with you, put in a Little Giant Generator, as many others have done, *to use up your surplus coke, and to rush up your holder when hard pressed.*

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The Double-Acting Gas Engine,

Under the Patents of Griffin, and Dick, Kerr & Co., of London and Kilmarnock.

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Single Cylinder.

Impulse Every Revolution.

(Two Strokes.)

15 to 500 Horse Power.

For General Work and Isolated Electric Plants.

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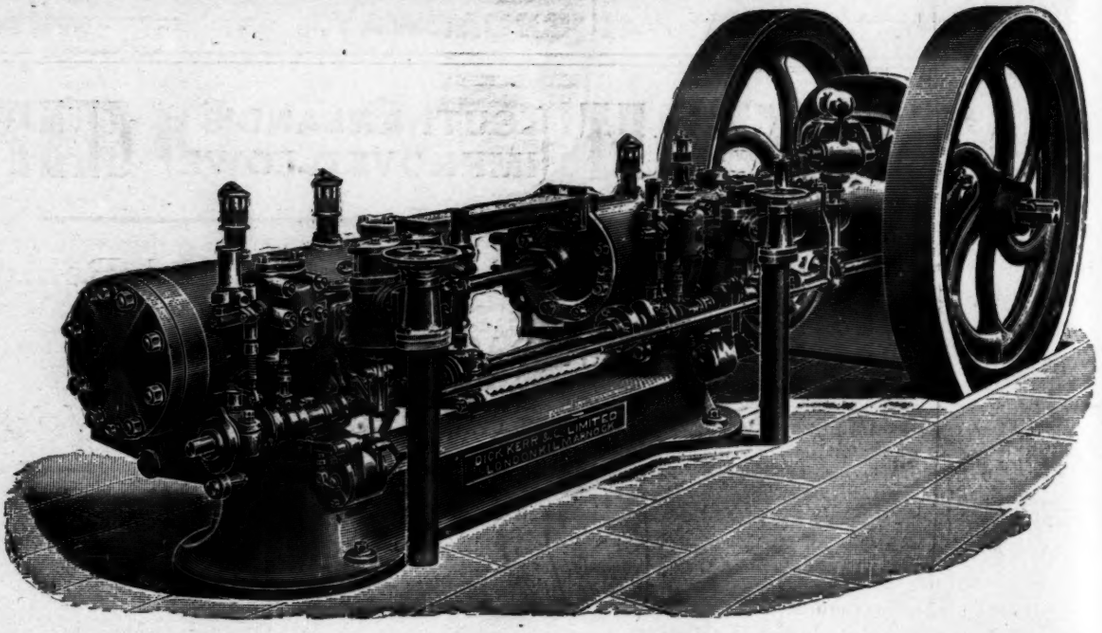
Tandem Cylinder. Impulse Every Stroke. 100 to 1,000 Horse Power.

For Central Stations and all work requiring extreme steadiness.



ESSENTIAL PRINCIPLE.—An impulse at each end of piston; using half force to each impulse; doubling the steadiness; reducing the wear on moving parts, and weight for given power. **CONSTRUCTION.**—The piston rod works through stuffing box in front end of cylinder, and connecting rod is carried in a cross-head working in a slide in frame, as in ordinary steam engine practice. All valves are of the poppet type, operated by cams on a single cam-shaft, giving positive movement to every working part. Tube or electric ignition. **RESULT.**—An engine of extreme simplicity and steadiness of action, the even wear on the cylinder and all working parts assuring increased economy, long life, and minimum cost in repairs. **RECORD.**—Successful and constant use in Great Britain for the past eight years. Address

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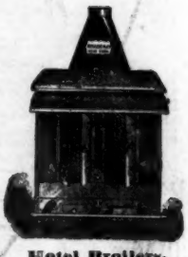

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In our position as Manufacturers, Wholesale and Retail Dealers, we have the facilities of PRACTICALLY testing the merits of all appliances offered, coming in close touch with the Consumer.

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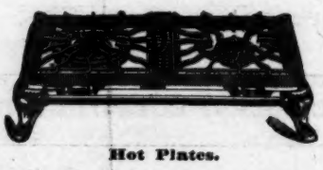

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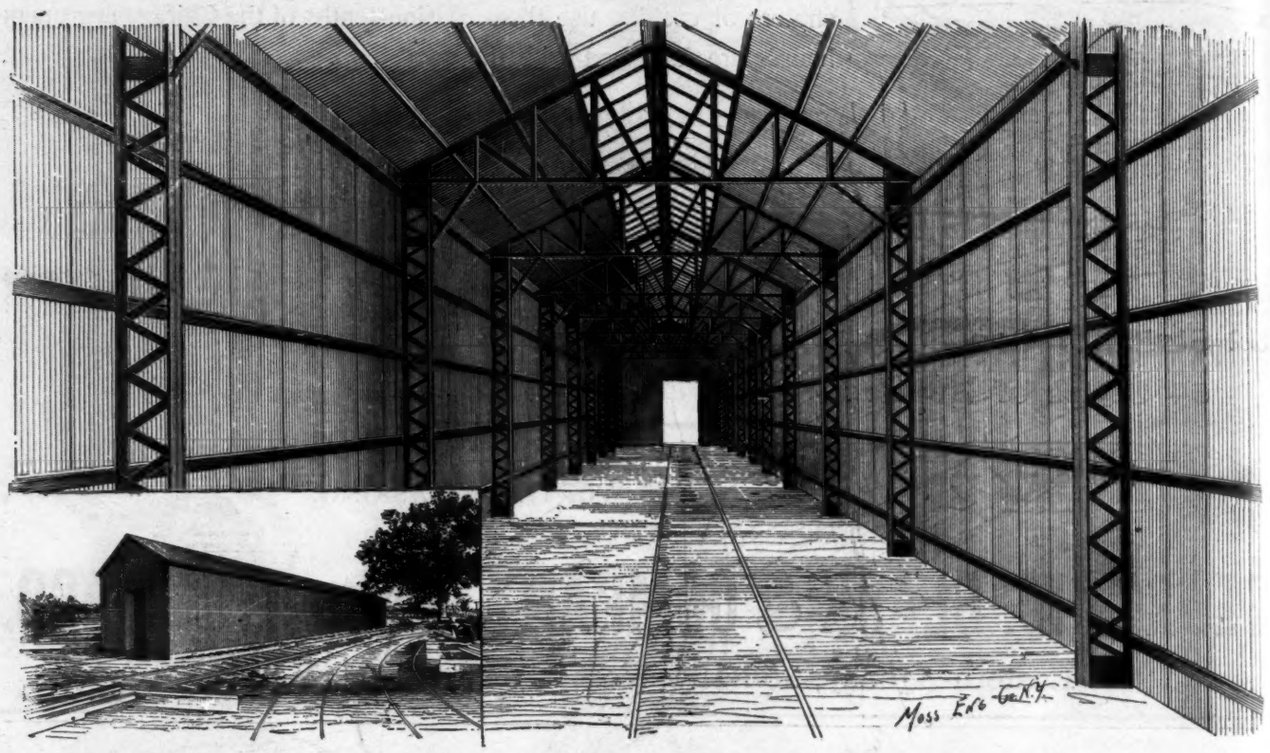

The above illustration is taken direct from a photograph, and is an interior view in a Store Room designed and built by us for our own use at East Berlin. The construction particularly commends itself on account of the large amount of side wall space applicable for storage purposes, the light being introduced entirely from the roof, no side windows being used, thus allowing all the wall space for storage.

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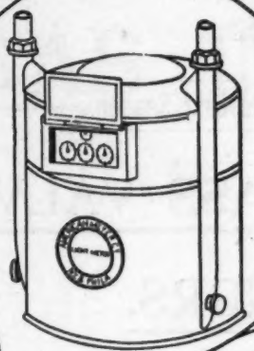

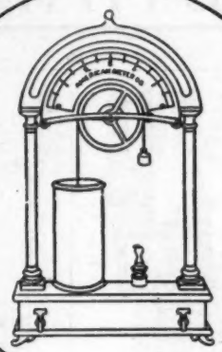

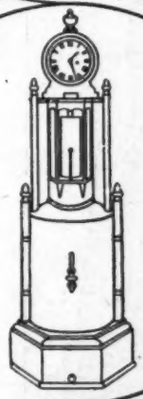

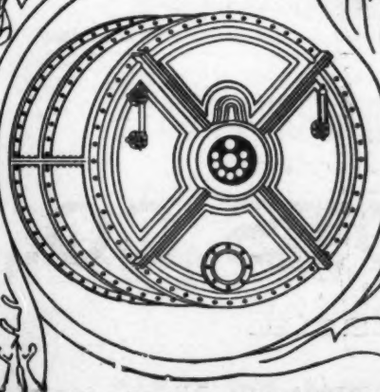

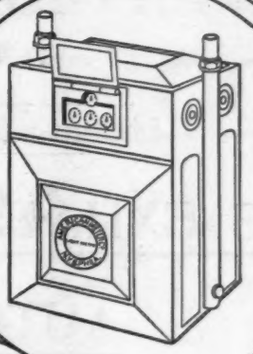

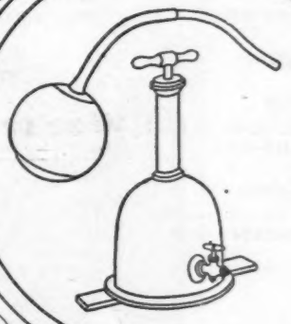

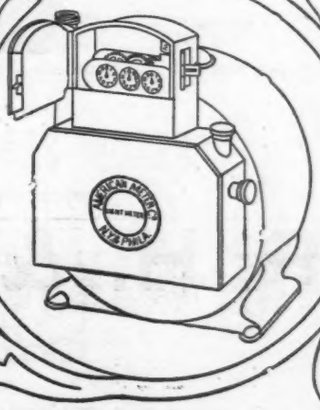

PUBLIC LIGHTING TABLE.

MAY, 1896.

Day of Week.	Table No. 1. Following the Moon. Date.	Light.	Extinguish.	Table No. 2. New York City. All Night Lighting. Light.	Extinguish.
				P.M.	A.M.
Fri.	1	7.20 PM	1.00 AM	6.45	4.00
Sat.	2	7.20	1.40	6.45	4.00
Sun.	3	7.30	2.10	6.45	4.00
Mon.	4	7.30 LQ	2.30	6.45	4.00
Tue.	5	7.30	3.00	6.45	4.00
Wed.	6	7.30	3.20	6.45	4.00
Thu.	7	7.30	3.40	6.55	3.40
Fri.	8	7.30	3.50	6.55	3.40
Sat.	9	7.30	3.50	6.55	3.40
Sun.	10	7.40	3.50	6.55	3.40
Mon.	11	7.40	3.50	6.55	3.40
Tue.	12	7.40 NM	3.50	6.55	3.40
Wed.	13	7.40	3.50	6.55	3.40
Thu.	14	7.40	3.50	7.00	3.30
Fri.	15	7.40	3.50	7.00	3.30
Sat.	16	7.40	3.50	7.00	3.30
Sun.	17	10.50	3.40	7.00	3.30
Mon.	18	11.20	3.40	7.00	3.30
Tue.	19	11.50 FQ	3.40	7.00	3.30
Wed.	20	12.20 AM	3.40	7.00	3.30
Thu.	21	12.40	3.40	7.10	3.15
Fri.	22	1.10	3.40	7.10	3.15
Sat.	23	1.40	3.40	7.10	3.15
Sun.	24	2.10	3.40	7.10	3.15
Mon.	25	No L.	No L.	7.10	3.15
Tue.	26	No L. FM	No L.	7.10	3.15
Wed.	27	No L.	No L.	7.10	3.15
Thu.	28	7.50 PM	10.40 PM	7.15	3.15
Fri.	29	7.50	11.30	7.15	3.15
Sat.	30	7.50	12.10 AM	7.15	3.15
Sun.	31	7.50	12.40	7.15	3.15

TOTAL HOURS LIGHTING DURING 1896.

By Table No. 1.	Hrs.Min.	By Table No. 2.	Hrs.Min.
January	220.40	January	423.20
February	207.00	February	367.40
March	193.00	March	355.35
April	174.10	April	298.50
May	164.00	May	264.50
June	142.10	June	234.25
July	142.10	July	243.45
August	150.50	August	280.25
September	163.00	September	321.15
October	193.10	October	374.30
November	207.00	November	401.40
December	237.30	December	433.45
Total, yr.	2194.40	Total, yr.	4000.00

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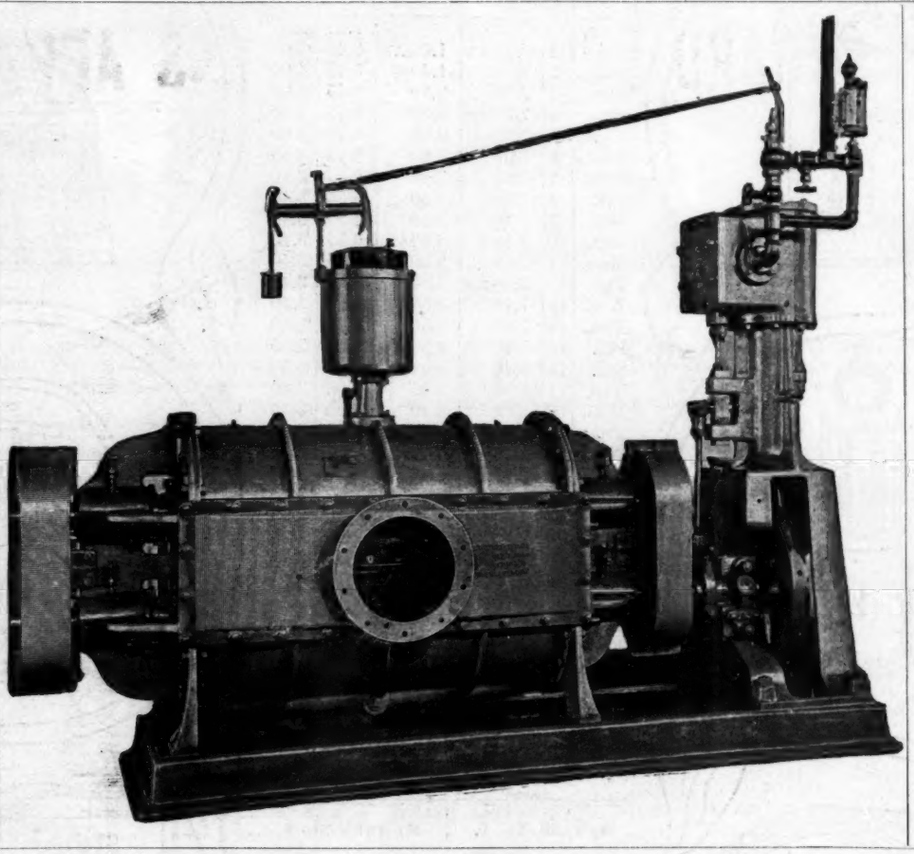

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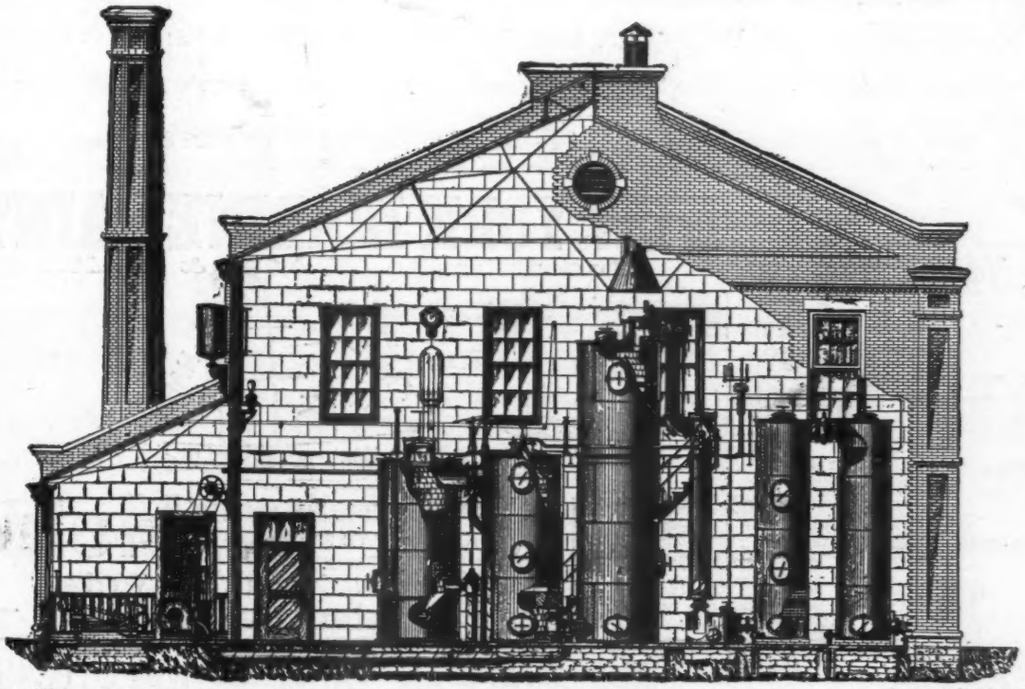

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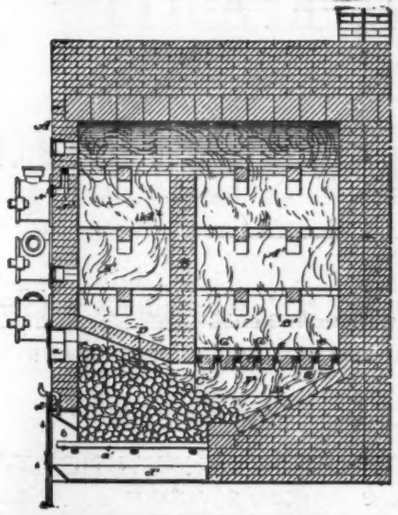

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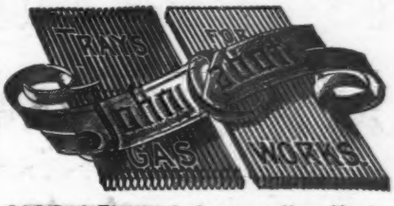

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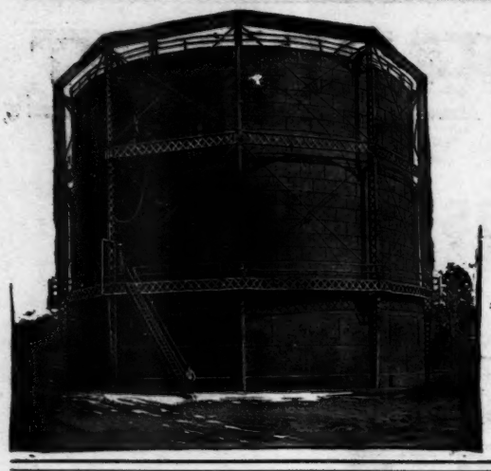

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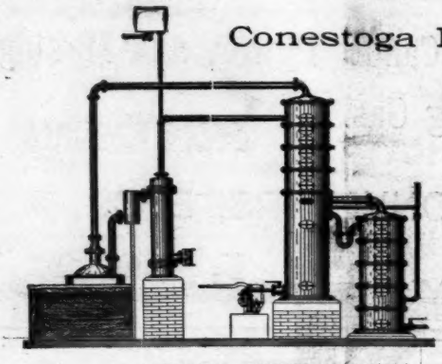

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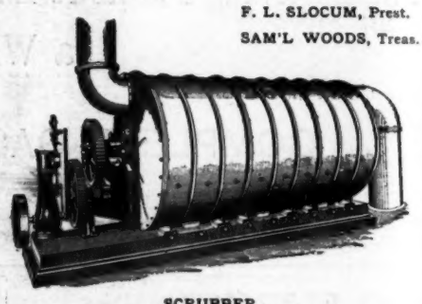

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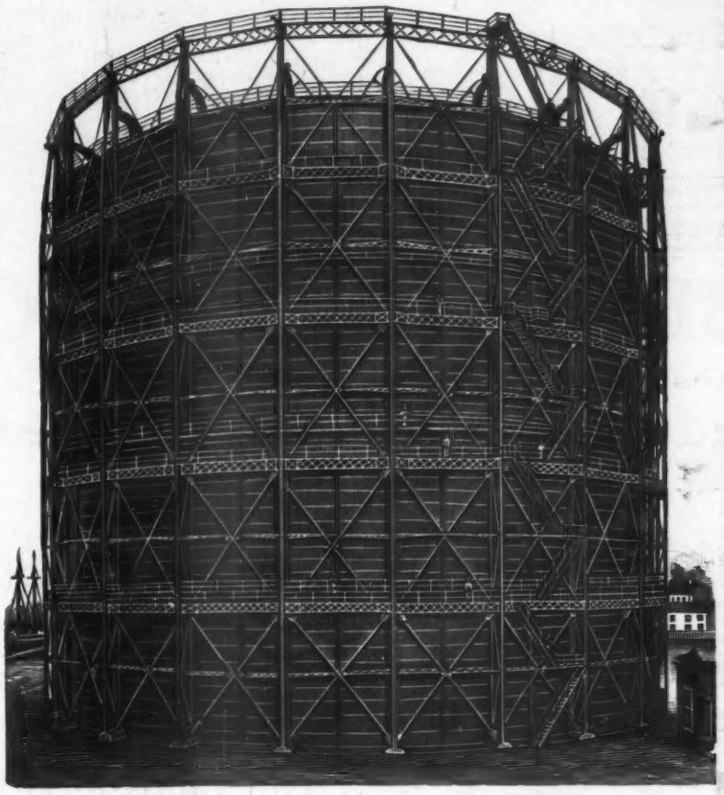

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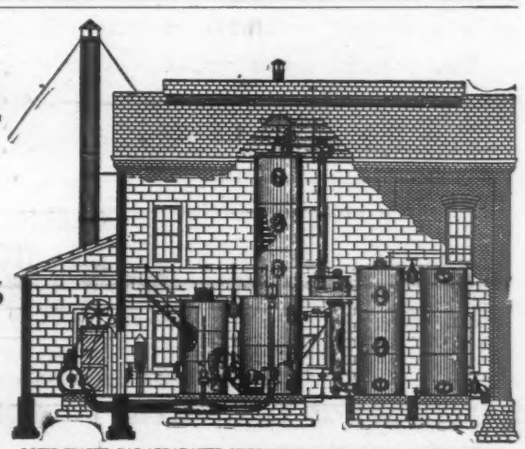

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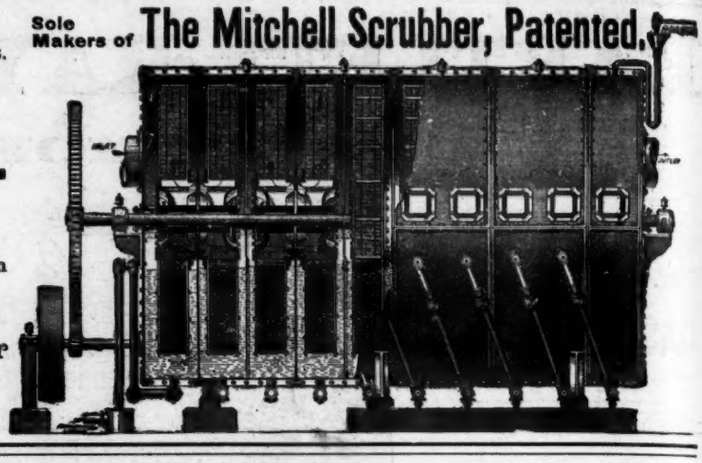

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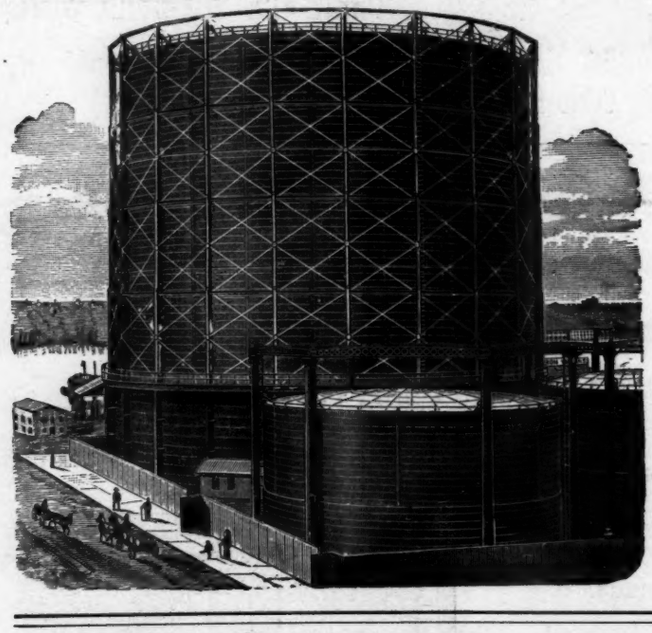

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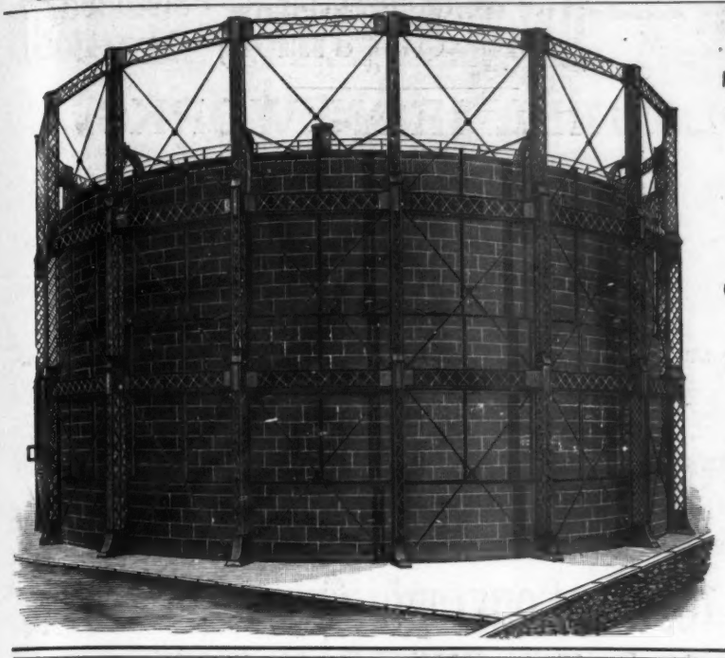

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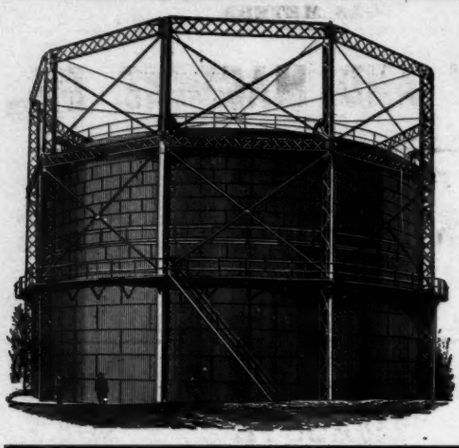

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